MINISTRY OF AGRICULTURE, EGYPT.

Technical and Scientific Service.
Bulletin No. 49. (Botanical Section).

Mycological Work in Egypt during the Period 1920-1922

By H. R. BRITON-JONES, B.Sc., D.I.C., A.R.C.S.

(Recommended for publication by the Publications Committee of the Ministry of Agriculture, which is not, as a body, responsible for the opinions expressed herein.)

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ERRATUM.

CONTENTS.

Page IV, 8th line: "*Vicea Faba*" *should read* "*Vicia Faba.*"
„ VII, 4th line: "DARNEI GRASS" *should read* "DARNEL GRASS."
„ VII, 8th line: "MELILOTUS SP." *should read* "MELILOTUS Spp."

In the List of Publications in English issued by the Ministry:—
Page 4, { 13th line:—61. After M.A. Bailey *add* "and J. Templeton."
{ 17th line:—63. After M.A. Bailey *add* "and T. Trought."

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COTTON.

PULSE.

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COTTON.

Introduction.

The sterile stages of the first two fungi dealt with in the present paper belong to the genus Rhizoctonia of the "Fungi Imperfecti." The genus has, during the last thirty years, received the attention of many mycologists in different parts of the world, particularly in Europe, India and America. The result of this has been a great increase in the bibliography and since the writer has been able to obtain only a few of the original papers for reference, it is not proposed to go into a detailed account of the historical information concerning the genus. It is necessary however to give a summary of the genus as accepted at the present time by the majority of mycologists.

The chief authorities on the genus Rhizoctonia in the United States and in Europe recognise, until a more critical study of the doubtful material is made, only two species. Convincing evidence of this is given by Duggar (14) who has examined material of all the known forms on different hosts from different countries, and who has had conferences with leading American and European authorities. For the form which possesses a fertile stage he gives the following synonymy :—

Corticium vagum B. and C.
Rhizoctonia solani Kühn (1858).
Rhizoctonia Betae Eidam (not Kühn) (1887).
Rhizoctonia Napaeae West (1846).
Rhizoctonia Rapae West (1852).
Hypochnus solani Prill. and Del. (1891).

According to information received from Butler it seems that "in Europe *Hypochnus solani* Pril. and Del. was the name almost

universally given, up to a few years ago, to the Basidiomycete which has as its sterile stage the fungus called *R. solani* Kühn by all modern workers in Europe. But a few years ago the genus *Hypochnus* was revised and the name of Prillieux and Delacroix's fungus was altered on technical grounds to *Corticium solani* (Pril. and Del.) Bourdot and Galzin (Bull. Soc. Myc. France XXVII, p. 248, 1911). *Corticium solani* Bourd. and Galz. is therefore the name now adopted by the mycologists of the Ministry of Agriculture in England (Report on occurence of Insect and Fungus pests on plants in England and Wales in 1918, Bd. of Agri. and Fish., Misc. Publs. No. 23, 1920).

The fertile stage of *Rhizoctonia solani* Kühn was first observed in the United States by Rolfs in 1903, on potato stems. This material was identified by Burt who referred it to the species *Corticium vagum* B and C. On account of its being parasitic, Burt gave the Berkeley and Curtis fungus a varietal name, *viz.*: *Corticium vagum* B and C var. *solani* Burt." Later, however, Burt in a letter to Peltier (28) stated that he does not believe that there is even a varietal difference between *Corticium vagum* B and C and that on the potatoes: hence he will drop var. *solani*. Peltier states further that according to Burt's classification *Hypochnus solani* Prill. and Del. becomes a synonym of *Corticium vagum* B and C. Butler also informs the writer that it is accepted by the great majority of workers in both continents that the European *Corticium solani* Bourdot and Galzin is the same as the American *Corticium vagum* B and C. Of the two names the writer prefers to use *Corticium vagum* B and C in accordance with the custom of giving precedence to the older name.

With regard to the second species of Rhizoctonia for which, up to the present, no fertile stage has been officially established Duggar (14) gives the following synonymy:—

Tuber parasiticum Bull. (1791).
Sclerotium Crocorum Pers. (1801).
Rhizoctonia Crocorum D.C. (1815).
Rhizoctonia Medicaginis D.C. (1815).
Thanatophytum Crocorum Nees. (1816).
Tuber Croci Duby. (1830).
Rhizoctonia Rubiæ Dene. (1837).
Rhizoctonia Dauci Rabenh. (1859).
Rhizoctonia violacea Tul. (1862).
Rhizoctonia Asparagi Fckl. (not Fr.) 1869.
Hypochnus violaceus Eriks. (1913).

Of the above names Duggar gives preference, and rightly so, to the oldest name, *viz.*: *R. Crocorum* (Pers.) D.C. In this connection he states that "this name, perhaps unfortunately, has priority over *R. Medicaginis* D.C. in that it is mentioned first by Fries (1823).

Though necessary, it may seem unwise to call the fungus *R. Crocorum*, inasmuch as it is far more widely distributed on alfalfa ; and, furthermore, because its dicotyledonous hosts are more numerous. *R. violacea* would be a most appropriate descriptive name (owing to the colour of the fungus), but it is obvious that this also would not conform to the rules."

Sore-Shin.

Previous Work in Egypt.

The first worker on "Sore-Shin" in Egypt was Fletcher (22) who stated that the damping off of cotton seedlings in 1902 was due to Pythium de Baryanum.

In 1905 and 1906 Balls (1) and (2) reinvestigated the disease. He called the causal organism "Atkinson's fungus" but he did not place it in its systematic position. Later, however, the same author (4) stated that he regarded the fungus as a degenerate Basidiomycete. It will be shown later that the fungus worked on by Balls was the same as the fungus described as causing sore-shin in the present paper although Atkinson's description of his sterile fungus, as quoted by Balls (1) holds good for both the species of Rhizoctonia described below.

Throughout the study of this disease no trace has been found of the fungus Pythium de Baryanum. Special plots of thickly-sown cress were grown with a view to obtaining Pythium in culture. In all the many cases of damped-off seedlings examined the cause was found to be due to the same fungus as that which causes sore-shin in cotton seedlings.

Occurrence.

Specimens of diseased cotton seedlings have been received in the laboratory for identification from almost every province in Egypt and in the spring of 1921 cotton seedlings attacked by sore-shin were examined in the field throughout Upper and Lower Egypt. The disease is, therefore, spread throughout the country but, the amount of the disease in any area of cotton depends on a number of factors the influence of which will be discussed later. Furthermore the ravages of this active parasite in Egypt are not by any means confined to cotton seedlings.

The same disease is also well-known in America. A similar disease of cotton seedlings is known in India but the cause is not the same fungus as in America and Egypt.

Description of the Disease.

The symptoms of the disease depend largely on the stage of development of the seedling at which it is attacked by the fungus, and the conditions of the temperature and moisture prevailing at the time. Forty-eight hours after sowing the young radicle bursts open the seed coat, and in many cases the former is attacked at this stage. The result is that further development is arrested and the fungus causes the young radicle and the cotyledons, which are still enclosed in the seed coat, to become soft and light brown in colour, due to the death of the tissues. This accounts for a very large number of the blank holes seen in a cotton field.

If, however, the seedlings are free from attack for the first few days after sowing they force the soil upwards, causing it to crack. This allows for better aeration of the soil immediately surrounding the developing seedlings. The air in the half-closed chamber so formed is very moist. Such conditions are almost perfect for the fungus which, as will be shown later, is to a very marked extent dependent on good aeration, and moisture. Cool weather at this stage prolongs these extremely favourable conditions to the fungus for a period of three or four days because the growth of the seedlings under ground is slow; the rate of evaporation is also slow thus preserving moisture conditions favourable to the growth of the fungus. Under these conditions the fungus attacks any part of the hypocotyl and a very large percentage of seedlings are killed. On removing the cracked soil above the seedlings the latter will be found as a soft, light-brown rotten mass covered with a copious growth of the whitish fungus hyphæ, which can be seen easily with the naked eye.

Should the seedlings manage to reach the surface and the cotyledons to open, then under normal conditions the chances are that the majority recover from the attack. Once the seedlings have reached the surface, they are attacked, if at all, invariably at the hypocotyl, just about the level of the soil. The reason for this is that the conditions of aeration and moisture are more suitable to the fungus at this point than at any other portion of the seedling above or below. Below the ground level moisture increases but with increase of moisture in soil there is a corresponding decrease in aeration so that the lack of oxygen below the surface of the ground becomes an inhibiting factor; above the level of the soil the aeration is very favourable to the growth of the fungus but, on the other hand, there is not sufficient moisture. Just about the ground level the balance between aeration and moisture is suitable for the fungus.

The following infection experiment shows that under favourable conditions of moisture and aeration the fungus is able to attack

the seedlings at any point of the hypocotyl, after the cotyledons have fully expanded. The fungus (*see* Experiment XIII) was placed near seedlings growing in sand in pots and then covered with a bell jar. The air under the bell jar, owing to the evaporation from the surface of the sand became saturated with moisture and the inside of the bell jar covered with dew. Under these conditions the fungus grew rapidly over the surface of the sand and the whole surface of the seedlings including the cotyledons. In a few days the whole of the hypocotyl above the surface turned a light brown colour and the seedlings were in different stages of collapse.

In the case of a seedling which recovers from the attack the plant forms a layer of cork to protect itself against the invading fungus and a brown scar is produced (resembling that shown in Plate I, Fig. 1) which persists throughout its life time. Sometimes, particularly in the case of early sown cotton, a shower of rain or a sudden drop in the temperature brings about conditions which are sufficiently favourable to the fungus and unfavourable to the seedling, so that a very large percentage of the seedlings are killed even after they have reached the surface and the cotyledons fully expanded. A case has been known where a cultivator sowed early and got very poor germination on account of sore-shin. After resowing he decided to water the whole crop in order to make certain that there would be sufficient moisture in the soil for the satisfactory germination of the resowing and as a stimulus to the young plants from the original sowing. The result, as would be expected, was disastrous since the majority of the seedlings from the original sowing were killed by sore-shin and resowing had to be repeated the second time.

A good many seedlings are also destroyed by the cutworm (*Agrotis ypsilon*) and the mole cricket (*Gryllotalpa vulgaris*). The injuries caused by these insects can be distinguished easily from sore-shin with the naked eye. The cutworm actually cuts the seedlings in two just above the level of the soil, and the mole cricket gnaws through the cortex, leaving a roughened and depressed surface. In no case do the tissues become light brown, soft and rotten, but dry up into a dark brown brittle thread. There are, of course, cases where seedlings are attacked by one of the insects as well as the fungus.

Isolation of the Fungus.

At first, some difficulty was experienced in obtaining pure cultures of the fungi which were present in the tissues of diseased seedlings. The method used was as follows :—

The diseased seedlings were brought into the laboratory and the adhering soil was removed by thoroughly washing under a tap. The diseased area of the hypocotyl was then cut off and placed in a

flask containing distilled water in which it was thoroughly washed. Finally it was removed, by means of sterilized forceps, into another flask and washed again carefully in several changes of sterilized water. Small pieces of the diseased tissues were then placed in tubes containing media such as Prune Agar and Potato wedges. Growth from these consisted of several kinds of Bacteria and four species of fungi, *viz.* :—

(i) *Alternaria* sp.
(ii) *Rhizopus nigricans* Ehr.
(iii) *Fusarium* sp.
(iv) *Rhizoctonia* sp.

The three which occurred most regularly in cultures were *Rhizopus nigricans*, *Fusarium* sp. and *Rhizoctonia* sp.

Pure cultures of Rhizopus and Fusarium were obtained by transferring on the point of a sterilized needle some spores of each into fresh tubes containing media. In the case of Rhizoctonia which formed no spores on culture media the mycelium was examined in sterilized water under a microscope and small portions teased out. In this way, after transplanting several times, a pure culture was obtained. Some weeks after the work had been commenced it was found that a pure culture of Rhizoctonia from diseased cotton seedlings could be obtained with great ease as follows :—

Diseased seedlings were washed in distilled water and then placed in sterilized water in a petri dish and left for forty-eight hours. At the end of this time the hyphæ of Rhizoctonia had grown outwards on the surface of the water in the form of a disc an inch or more in diameter. The mycelium on the outside of the disc was then placed on culture media in tubes and often, without any further transplanting a pure culture would be obtained.

Infection Experiments on Cotton.

In view of the regularity with which *R. nigricans*, *Fusarium*, and *Rhizoctonia* sp. were obtained in culture from diseased seedlings, and the knowledge that all three can, under favourable conditions, become parasitic, it was decided to investigate the parasitism of each one separately with regard to sore-shin.

Preliminary experiments were carried out by sowing a number of seeds in pots containing unsterilized soil but it soon became apparent that no reliable results could be obtained from them owing to the fact that the seedlings in all the pots, controls and others, became diseased more or less in the same proportion. Owing to the difficulty of sterilizing sufficient quantity of soil it was decided to use sun-dried sand as

being more likely to be free from Rhizoctonia and eliminating the possibility of seedlings being held under by lumps of soil.

Some experiments were also carried out, using sand and tap water because of the small size of the distilling apparatus in the laboratory and the large amount of water needed. The pots had to be watered every two days owing to rapid evaporation. These experiments gave definite results but in some cases the control plants became diseased showing that the parasite was present either in the tap water or in the sun-dried sand. The above experiments, although not given in detail, were interesting since they showed how widely distributed the parasite is in both normal Egyptian soil and water from the main supply.

Throughout the following experiments the seeds were sown in shallow dishes which measured about 8 inches in diameter and 3 inches in depth. The dishes were made of earthenware and glazed on the inside. They were watered according to their requirements, some host seedlings requiring more than others, and the texture of the sand, although taken from the same lot, varying in different dishes. The experiments were carried out in the laboratory and not out of doors, owing to interference by small birds and the rapid rate of evaporation of the water in the dishes at that time of the year. This is of interest because had it been possible to carry out the experiments out of doors the results would have been entirely different. The temperature would have been too high for the rapid growth of the fungus. A negative result in the latter case would have been entirely misleading in regard to the parasitism of the fungus. At the time of sowing, the sand in the dishes was thoroughly wetted, and, generally speaking, kept moist by subsequent waterings every two days. Observations were not made for more than a few days after the appearance of the seedlings above the surface because, being sown in sand, they would have wilted in the absence of the parasite.

In order to make the description of the treatment in these experiments as condensed as possible, the following terms will be understood to have meanings as below : —

Sterilized Dish.—The dish was sterilized by immersion in a two per cent solution of copper sulphate for 15–20 minutes.

Sun-dried Sand.—Means that the sand has been exposed to the heat of the sun for several weeks.

Sterilized Sand.—Small amounts (about 4 litres) of sand were sterilized by heating over a strong gas burner for $2\frac{1}{2}$ to 3 hours.

The usual procedure was to place the sand in the dishes and to add water until it was thoroughly wetted. A hole was then made in the sand and the seed placed in the hole and covered with wet sand.

In the case of the infected dishes a small piece of potato on which the fungus was growing was placed in contact with the seed and then covered with sand. No fungus was placed in the control pots; otherwise treatment was the same throughout any one experiment.

Unless otherwise stated the variety of cotton seed used was Sakellarides.

Experiment I.

No. of Dish.	Treatment.	Date of Sowing.	Date of Appearance of Seedling above Sand.	No. of Seedlings appeared.	Remarks.
1	Sterilized dish. Sun-dried sand. 12 selected seeds after soaking in distilled water for 24 hours. Watered with distilled water. (Control).	12–5–1920	20–5–1920	8	Seedlings in all dishes healthy up till 23–5–1920.
2	ditto. (Control).	,,	,,	9	
3	*Rhizopus nigricans* placed with 12 seeds.	,,	,,	10	
4	ditto.	,,	,,	9	
5	ditto.	,,	,,	11	

Experiment II.

No. of Dish.	Treatment.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	Remarks.
1	As in Experiment I, but only 6 seeds sown. (Control).	19–5–1920	27–5–1920	6	Seedlings in all dishes healthy up till 30–5–1920.
2	ditto (Control).	,,	,,	5	
3	*Fusarium* sp. placed with 6 seeds	,,	,,	5	
4	ditto.	,,	,,	5	
5	ditto.	,,	,,	4	
6	ditto.	,,	,,	6	

The result of Experiment III confirmed those obtained in preliminary experiments carried out with sand and tap water, namely, that the cause of sore-shin is the *Rhizoctonia* sp.

EXPERIMENT III.

No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
1	As in Experiment I, but only 5 seeds sown. (Control).	19–5–1920	27–5–1920	4	Healthy.
2	ditto (Control).	,,	,,	4	,,
3	*Rhizoctonia* sp. placed with 5 seeds.	,,	,,	0	Seedlings killed before reaching surface.
4	ditto.	,,	,,	0	
5	ditto.	,,	,,	0	*Rhizoctonia* sp. isolated.

EXPERIMENT IV.

No. of Dish.	TREATMENT.	Date of Sowing.	Date of Examination of Seedlings.	No. of Seedlings.	REMARKS.
1	Petri dish containing filter paper moistened with distilled water was sterilized in an autoclave. Three seeds (24 hours soaking in distilled water and selected) placed in petri dish. (Control).	21–5–1920	25–5–1920	3	Healthy.
2	ditto.	,,	..	3	Two seedlings healthy and 1 diseased. Latter examined microscopically and found to be invaded by *Rhizoctonia* sp.
3	*Fusarium* sp. placed with seeds.	,,	,,	3	Healthy :—
4	ditto.	,,	,,	3	No sign of the fungus being parasitic although growing over surface of seedlings. No mycelium found in tissues.
5	ditto.	,,	,,	3	
6	ditto.	,,	,,	3	

EXPERIMENT V.

No. of Pot.	DESCRIPTION.	TREATMENT.	REMARKS.
1	Four healthy seedlings growing in pot containing soil.	Seedlings pricked near ground level with sterilized needle on 21–5–1920. (Control).	No sign of disease up to 26 5 1920.
2	Six healthy seedlings growing in pot containing soil.	As above but *Rhizopus nigricans* placed on wound.	

EXPERIMENT VI.

No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
1	As in Experiment I, but only 5 seeds sown. (Control).	31–5–1920	8–6–1920	4	Healthy.
2	ditto. (Control).	,,	,,	4	,,
3	*Rhizoctonia* sp. isolated in Experiment III, placed with 5 seeds.	,,	,,	0	Cracks in sand showed that seeds had germinated but were killed by *Rhizoctonia* sp. before reaching the surface. *Rhizoctonia* sp. isolated from seedlings in pots 3 and 7.
4	ditto.	,,	,,	0	
5	ditto.	,,	,,	0	
6	ditto.	,,	,,	0	
7	ditto.	,,	,,	0	
8	With *Fusarium* sp. placed with 5 seeds.	,,	,,	3	Healthy.
9	ditto.	,,	,,	4	,,
10	ditto.	,,	,,	4	,,
11	ditto.	,,	,,	5	,,
12	ditto.	,,	,,	5	,,

EXPERIMENT VII.

No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings. appeared.	REMARKS.
1	As in Experiment I, 5 seeds sown. (Control).	1–6–1920	8–6–1920	4	Healthy.
2	ditto. (Control).	,,	,,	5	,,
3	*Rhizoctonia* sp. placed with seed.	,,	,,	0	All seedlings killed before reaching surface.
4	ditto.	,,	,,	0	
5	ditto.	,,	,,	0	*Rhizoctonia*
6	ditto.	,,	,,	0	sp. isolated.

EXPERIMENT VIII.

No. of Bottle.	TREATMENT.	Date of Sowing.	Date of Observations.	REMARKS.
1	Cotton wool placed at bottom of stoppered bottle moistened with distilled water and sterilized in autoclave. Five seeds were soaked in 2 per cent solution of $CuSo_4$ for 10 minutes dried and then placed in the sterilized bottle stoppered. (Control).	1–6–1920	6–6–1920	Four healthy seedlings and 1 failed to germinate.
2	ditto. (Control).	,,	,,	Three healthy seedlings and 2 failed to germinate.
3	As above but *Rhizoctonia* sp. isolated from Experiment III placed with seeds.	,,	,,	All seedlings killed at commencement of germination and *Rhizoctonia* sp. found in tissues.
4	ditto.	,,	,,	
5	ditto.	,,	,,	
6	ditto.	,,	,,	

EXPERIMENT IX.

No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
1	As in Experiment I, 5 seeds sown. (Control).	8–6–1920	14–6–1920	5	Healthy.
2	ditto. (Control).	,,	,,	4	,,
3	With *Rhizoctonia* sp. isolated from Experiment III.	,,	,,	4	Two healthy, 2 diseased. By 17–6–1920 3 seedlingsdead and 1 standing although diseased.
4	ditto.	,,	,,	1	Diseased. Dead on 17–6–1920.

EXPERIMENT X.

No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
1	As in Experiment I, but 5 seeds sown without soaking. (Control).	16 6 1920	22 6 1920	5	Sore-shin present. Possibly due to to fact that some of the sand had been previously used in infected dishes.
2	ditto. (Control).	,,	,,	4	
3	ditto. (Control).	,,	,,	1	
4	ditto. (Control).	,,	,,	5	
5	ditto. (Control).	,,	,,	4	
6	ditto (Control).	,,	,,	3	
7	ditto. (Control).	,,	--	0	
8	ditto. (Control).	,,	22–6–1920	2	
9	ditto. (Control).	,,	--	0	
10	ditto. (Control).	,,	22–6–1920	5	

EXPERIMENT X (*continued*).

No. of Dish.	TREATMENT	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
11	With *Rhizoctonia* sp., placed with 5 seeds	16–6–1920	—	0	
12	ditto.	,,	—	0	
13	ditto.	,,	—	0	
14	ditto.	,,	—	0	
15	ditto.	,,	—	0	
16	ditto.	,,	—	0	
17	ditto.	,,	22–6–1920	1	Diseased. Dead on 23–6–1920.
18	ditto.	,,	—	0	
19	ditto.	,,	22–6–1920	3	One dead, 1 diseased, and 1 healthy. On 24–6–1920. 2 dead, 1 diseased but not killed.
20	ditto.	,,	—	0	
21	ditto.	,,	—	0	
22	ditto.	,,	—	0	
23	ditto.	,,	—	0	
24	ditto.	,,	22–6–1920	1	Diseased and collapsed. *Rhizoctonia* sp. isolated on 26–6–1920.
25	ditto.	,,	—	0	

EXPERIMENT XI.

No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
1	Five seeds (soaked in distilled water for 24 hours and selected). Sterilized sand. Sterilized dishes. Distilled water used. (Control).	23–6–1920	28-6-1920	5	Seedlings healthy up till 1-7-1920.
2	ditto. (Control).	,,	,,	5	
3	*Rhizoctonia* sp., placed with seed.	,,	—	0	
4	ditto.	,,	—	0	
5	ditto.	,,	—	0	
6	ditto.	,,	28-6-1920	2	Both diseased. 1 dead on 29-6-1920. The other collapsed on 30-6-1920. *Rhizoctonia* sp. isolated.
7	ditto.	,,	—	0	
8	ditto.	,,	—	0	
9	ditto.	,,	—	0	

EXPERIMENT XII.

No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
1	As in Experiment XI, except that seeds were soaked for 18 hours. (Control).	24-6-1920	29-6-1920	5	Healthy.
2	ditto. (Control).	,,	,,	5	,,
3	*Rhizoctonia* sp. placed with seeds.	,,	—	0	
4	ditto.	,,	—	0	
5	ditto.	,,	—	0	
6	ditto.	,,	29-6-1920	1	Diseased. Collapsed on 30-6-1920 *Rhizoctonia* sp. isolated.
7	ditto.	,,	—	0	
8	ditto.	,,	—	0	

EXPERIMENT XIII.

No. of Dish.	TREATMENT.	Date of Infection.	No. of Seedlings.	REMARKS.
1	Control No. 1, Experiment XII, covered with bell jar (Control).	—	5	All seedlings healthy uptill 4-7-1920.
2	*Rhizoctonia* sp. placed on surface of sand near seedlings in control No. 2, Experiment XII, and then covered with bell jar. *Rhizoctonia* sp. isolated from Experiment VI used.	1-7-1920	5	3-7-1920 seedlings diseased and fungus growing on surface of sand and seedlings. 4-7-1920 all seedlings in different stages of collapse. *Rhizoctonia* sp. isolated.

Experiment XIV.

Variety of Cotton.	No. of Dish.	Treatment.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings Appeared.	Remarks.		
						On 30-7-1920.	On 1-8-1920.	On 2-8-1920.
Nubari ...	1	As in Experiment XI. Five seeds sown. (Control).	25-7-1920	30-7-1920	5	Healthy.	Healthy.	Healthy.
	2	With *Rhizoctonia* sp.	,,	,,	2	1 diseased 1 healthy	2 diseased	2 collapsed
	3	ditto.	,,	,	4	Diseased	3 collapsed 1 standing	3 collapsed 1 standing diseased
Ashmuni...	4	As in Experiment XI. Five seeds sown. (Control).	,,	,,	5	Healthy	Healthy	Healthy.
	5	With *Rhizoctonia* sp.	,,	,,	4	Diseased	1 collapsed 3 standing	1 collapsed 3 standing (diseased)
	6	ditto.	,,	—	0	—	—	—
Pelion ...	7	As in Experiment XI. Five seeds sown. (Control).	,,	30-7-1920	5	Healthy	Healthy	Healthy
	8	With *Rhizoctonia* sp.	,,	,,	4	1 collapsed 2 diseased 1 healthy	1 collapsed 3 diseased but standing	2 collapsed 2 diseased but standing
	9	ditto.	,,	,,	2	2 diseased	2 diseased but standing	1 collapsed 1 standing

EXPERIMENT XIV (*continued*).

Variety of Cotton.	No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings Appeared.	REMARKS.		
						On 30–7–1920.	On 1–8–1920.	On 2–8–1920.
ASSILI ...	10	As in Experiment XI. Five seeds sown. (Control).	25–7–1920	30–7–1920	5	Healthy	Healthy	Healthy
	11	With *Rhizoctonia* sp.	,,	—	0	—	—	—
	12	ditto.	,,	—	0	—	—	—
CASULI ...	13	As in Experiment XI. Five seeds sown. (Control).	,,	30–7–1920	4	Healthy	Healthy	Healthy
	14	With *Rhizoctonia* sp.	,,	—	0	—	—	—
	15	ditto.	,,	—	0	—	—	—
ZAGORA ...	16	As in Experiment XI. Five seeds sown. (Control).	,,	30–7–1920	5	Healthy	Healthy	Healthy
	17	With *Rhizoctonia* sp.	,,	—	0	—	—	—
	18	ditto.	,,	—	0	—	—	—

Experiment XIV was carried out with a view to ascertaining whether any of the best varieties of Egyptian cotton are immune or partially immune to the disease. In the case of Nubari and Pelion six seedlings reached the surface but this does not point to any resistant properties of these varieties because as can be seen these seedlings were mostly diseased and collapsed later. Furthermore, in experiments of this kind conditions in each dish cannot be kept absolutely the same. For instance, the variation might be due to the fact that there were different amounts of water in the dishes and this would, of course, alter the temperature in the seedbed. Those with more water would be lower in temperature than the others, and would therefore, be more liable to be killed by the fungus before reaching the surface. It would be interesting to find out whether cotton with fuzzy seed would be more attacked than others apart from any inherent properties of susceptibility. The fuzz would tend to hold air even in very wet soil so that the fungus could attack the seedling very readily at the very commencement of germination. Further, the presence of air between the fuzz fibres might have an effect on the rate of germination of the seed.

The results of the above experiments show that *Rhizopus nigricans* Ehr. cannot infect cotton seedlings in Egypt either as a true parasite or a wound parasite. It has not been established, however, that this fungus does not hasten the death of cotton seedlings which have been attacked by sore-shin. The species of Fusarium isolated was also unable to infect cotton seedlings. The extreme regularity with which the above two fungi appeared in cultures made from diseased seedlings is due to the fact that they are widely distributed in the soil and are very active saprophytes. So far then it can be definitely stated that the cause of sore-shin in Egypt is due to a *Rhizoctonia* sp.

Media.

The chief culture media used in the course of this investigation were :—

(i) *Prune Agar.*—Five prunes were taken and the stones extracted. The stoneless prunes were then boiled in 100 ccs. of water for 5 minutes and water added to make 500 ccs. of the prune extract.

Agar	7·5 grs.
Extract	500 ccs.

This is identical with Agar Medium C used by Shaw (31) and taken from it.

(ii) *Potato Wedges.*—Some absorbent cotton wool was placed at the bottom of boiling tubes to about an inch in depth. The cotton wool was then saturated with water and a wedge-shaped piece of potato placed on its surface.

(iii) *Carrot Wedges.*—As in (ii), but wedge-shaped pieces of carrot were used in place of potato.

All tubes were plugged with absorbent cotton wool because the non-absorbent was not available at the time.

The above is given in more or less detail because, as will be seen later, the growth of the fungus particularly with regard to development and size of the sclerotia varied to a great extent on the different media.

Other Host Plants.

At the time when the infection experiments on cotton were being carried out and for some time afterwards the fungus was identified merely as a species of Rhizoctonia. It was of scientific and economic importance, therefore, to find out how the behaviour of the fungus with regard to seedlings of other plants compared with that of some forms of Rhizoctonia in other countries. According to Duggar (15) some of the various hosts upon which forms of Rhizoctonia allied to *Corticium vagum* B and C var. *solani* Burt have thus far been found in America are as follows :—

Sugar Beet (*Beta vulgaris*).
Bean (*Phaseolus vulgaris*).
Carrot (*Daucus carota*).
Cabbage and Cauliflower (*Brassica oleracea*).
Cotton (*Gossypium hirsutum*).
Lettuce (*Lactuca sativa*).
Potato (*Solanum tuberosum*).
Radish (*Raphanus sativus*).
Sweet Potato (*Ipomoea Batatas*).
Pumpkin (*Cucurbita Pepo*).
Watermelon (*Citrullus vulgaris*).
Garden pea (*Pisum sativum*), etc.

as well as upon many species of ornamental plants and weeds. In India (31) the genus Rhizoctonia seems to have a wide range of hosts including :—

Ground Nut (*Arachis hypogaea*).
Cow Pea (*Vigna catiang*).
Jute (*Corchorus capularis*).
Soy Bean (*Glycine soja*).
Dolichos lablab.
Trichosanthes cucumerina.
Mulberry (*Morus alba*).
Cotton (*Gossypium* sp.).

The method of infection in the following experiments was exactly the same as that used in the preceding experiments on cotton. A small piece of potato or Agar, on which the fungus was growing in pure culture, was placed with the seeds in the sand. If the fungus had been placed on the surface of the sand after the appearance of the seedlings it is doubtful, owing to the rapid evaporation from the surface of the sand, whether infection would have taken place. Its failure to infect would have been no proof of its being non-parasitic.

Experiment I.

Name of Plant.	No. of Dish.	Treatment.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	Remarks.
Castor	1	Sterilized dish, sundried sand, distilled water, 5 seeds. (Control).	9–6–1920	20–6–1920	5	Healthy.
	2	ditto. (Control).	,,	,,	5	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	,,	3	Diseased. Not killed.
	4	ditto.	,,	—	0	—
	5	ditto.	,,	20–6–1920	3	2 badly diseased. 1 killed.
Sesame	1	As in dish No. 1 above. (Control).	9–6–1920	15–6–1920	4	Healthy.
	2	ditto. (Control).	,,	,,	5	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	15–6–1920	1	Diseased. Killed later.
	5	ditto.	,,	—	0	—
Pumpkin	1	As in dish No. 1 above. (Control).	9–6–1920	15–6–1920	5	Healthy.
	2	ditto. (Control).	,,	,,	4	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	15–6–1920	3	1 healthy. 2 diseased. *Rhizoctonia* sp. found in tissues.
Lubia ...	1	As in dish No. 1 above. (Control).	9–6–1920	15–6–1920	5	Healthy.
	2	ditto. (Control).	,,	,,	5	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	,,	2	Diseased. *Rhizoctonia* sp. found in tissues.
	4	ditto.	,,	—	0	—
	5	ditto.	,,	15–6–1920	1	Healthy.

EXPERIMENT I (*continued*).

Name of Plant.	No. of Dish.	TREATMENT.	Date. of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
CABBAGE	1	As in dish No. 1 above. (Control).	9–6–1920	15–6–1920	1	Healthy.
	2	ditto. (Control).	,,	,,	1	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	,,	1	Diseased and killed by 16–6–1920. *Rhizoctonia* sp. found in tissues.
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—

EXPERIMENT II.

Name of Plant.	No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
LUCERNE	1	Sterilized dish, sundried sand, tap water. 5 seeds sown. (Control).	13–6–1920	—	0	—
	2	ditto. (Control).	,,	16–6–1920	4	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—
BAMIA ...	1	As in dish No. 1 above. (Control).	13–6–1920	20–6–1920	2	Healthy.
	2	ditto. (Control).	,,	,,	1	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—
EARTH-NUT.	1	As in dish No. 1 above. (Control).	13–6–1920	22–6–1920	5	Healthy.
	2	ditto. (Control).	,,	,,	5	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—		—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—

EXPERIMENT II (*continued*).

Name of Plant.	No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
MELON	1	As in dish No. 1 above. (Control).	13–6–1920	21–6–1920	2	Healthy.
	2	ditto. (Control).	,,	,,	3	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—
RADISH	1	As in dish No. 1 above. (Control).	13–6–1920	16–6–1920	4	Healthy.
	2	ditto. (Control).	,,	,,	4	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—
GARDEN PEAS	1	As in dish No. 1 above. (Control).	13–6–1920	19–6–1920	5	Healthy.
	2	ditto. (Control).	,,	,,	4	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—

EXPERIMENT III.

Name of Plant.	No. of Pot.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
SESAME	1	Sterilized flower pot, sun-dried sand, tap water. Five seeds. Surface of pot covered with wooden board for protection against insects. No. fungus. (Control).	21–6–1920	26–6–1920	4	Healthy.
	2	ditto. (Control).	,,	,,	2	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—

EXPERIMENT III (*continued*).

Name of Plant.	No. of Pot.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
RADISH	1	As in pot No. 1 above. No fungus. (Control).	21–6–1920	24–6–1920	4	Healthy.
	2	ditto.	,,	,,	5	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—
LETTUCE	1	As in pot No. 1 above. No fungus. (Control).	21–6–1920	26–6–1920	2	Healthy.
	2	ditto. (Control).	,,	,,	1	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—
CASTOR OIL	1	As in pot No. 1 above. No fungus. (Control).	21–6–1920	1–7–1920	4	Healthy.
	2	ditto. (Control).	,,	,,	4	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	1–7–1920	2	Diseased, killed by 2–7–1920.
	5	ditto.	,,	,,	1	Diseased, killed by 2–7–1920 *Rhizoctonia* sp. in tissues.
PUMPKIN	1	As in pot No. 1 above. No fungus. (Control).	21–6–1920	28–6–1920	3	Healthy.
	2	ditto. (Control).	,,	,,	5	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	30–6–1920	3	Diseased, killed by 3–7–1920.

EXPERIMENT III (*continued*).

Name of Plant.	No. of Pot.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
PUMPKIN	4	With *Rhizoctonia* sp. from cotton.	21–6–1920	30 6 1920	1	Diseased, killed by 3–7–1920 *Rhizoctonia* sp. in tis sues.
	5	ditto.	,,	,,	2	Diseased, killed by 3–7–1920.
CABBAGE	1	As in pot No. 1 above. No fungus. (Control).	21–6–1920	26–6–1920	5	Healthy.
	2	ditto. (Control).	,,	,,	3	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—
LUCERNE	1	As in pot No. 1 above. No fungus. (Control).	21–6–1920	24–6–1920	5	Healthy.
	2	ditto. (Control).	,,	,,	3	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—
WATER MELON	1	As in pot No. 1 above. No fungus. (Control).	21–6–1920	28–6–1920	2	Healthy.
	2	ditto. (Control).	,,	,,	3	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—
LUBIA	1	As in pot No. 1 above. No fungus (Control).	21–6–1920	26–6–1920	5	Healthy.
	2	ditto. (Control).	,,	,,	3	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—

EXPERIMENT III (*continued*).

Name of Plant.	No. of Pot.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
PEAS	1	As in pot No. 1 above. No fungus. (Control).	21–6–1920	26–6–1920	5	Healthy.
	2	ditto. (Control).	,,	,,	5	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	,,	1	Diseased, killed by 28 6 1920.
	4	ditto.	,,	,,	1	Healthy 30 6 1920 small scar on stem.
	5	ditto.	,,	,,	2	Diseased, killed by 29 6 1920.
EARTH-NUT	1	As in pot No. 1 above. No fungus. (Control).	21–6–1920	30–6–1920	2	Healthy.
	2	ditto. (Control).	,,	,,	5	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	2–7–1920	1	Diseased, not killed.
	4	ditto.	,,	1 7 1920	2	Diseased. killed by 2 7 1920.
	5	ditto.	,,	,,	1	Diseased, not killed.
BAMIA	1	As in pot No. 1 above. No fungus. (Control).	21–6–1920	27–6–1920	3	Healthy.
	2	ditto. (Control).	,,	,,	4	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	,,	1	Diseased, killed by 28 6 1920.
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—

NOTE.—Earth-nut: Pots Nos. 3, 4 and 5. Uppermost part of seedings most attacked. Also scars at ground level.

EXPERIMENT III (*continued*).

Name of Plant.	No. of Pot.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
CARROT	1	As in pot No. 1 above. No fungus. (Control).	21–6–1920	—	0	–
	2	ditto.	,,	29–6–1920	4	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—

NOTE.—On 27–6–1920 a whitish mycelium was growing on surface of sand in infected pots and on the sides of pots. This was examined and found to be *Rhizoctonia* sp. Diameter of growth 6 inches. Rate of growth 1 inch per diem.

It is highly probable that the cause of uneven germination in controls was due to the presence of *Rhizoctonia* sp. in the tap water or in the sun-dried sand. In spite of this it is, of course, natural to find better germination in the controls than in the infected pots since the fungus in the latter was placed in greater quantity in actual contact with the seed.

EXPERIMENT IV.

Name of Plant.	No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
PEAS	1	Sterilized dish, sterilized sand, 5 seeds, distilled water. (Control).	26–6–1920	3–7–1920	5	Healthy.
	2	ditto. (Control).		,,	5	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	*Rhizoctonia* sp. isolated from seeds.
	4	ditto.	,,	—	0	
	5	ditto.	,,	—	0	—
LUBIA	1	As in dish No. 1 above. (Control).	26–6–1920	3–7–1920	4	Healthy.
	2	ditto. (Control).	,,	,,	5	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	*Rhizoctonia* sp. isolated from seeds.
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	

EXPERIMENT IV (*continued*).

Name of Plant.	No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
BAMIA	1	As in dish No. 1 above. (Control).	27–6–1920	3–7–1920	2	Healthy.
	2	ditto. (Control).	,,	,,	3	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	*Rhizoctonia* sp. isolated from seeds.
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—
EARTH NUT.	1	As in dish No. 1 above. (Control).	27–6–1920	7–7–1920	4	Healthy.
	2	ditto. (Control).	,,	,,	5	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	—
	4	ditto.	,,	—	0	—
	5	ditto.	,,	7–7–1920	3	Diseased, not killed. *Rhizoctonia* sp. isolated.
WATER MELON.	1	As in dish No. 1 above. (Control).	27–6–1920	3–7–1920	2	Healthy.
	2	ditto. (Control).	,,	,,	4	Healthy.
	3	With *Rhizoctonia* sp. from cotton.	,,	—	0	*Rhizoctonia* sp. isolated.
	4	ditto.	,,	—	0	—
	5	ditto.	,,	—	0	—

EXPERIMENT V.

Infections made with *Rhizoctonia* sp. isolated from :—	No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	Date of Seedlings appeared.	REMARKS.
	1	Sterilized sand, sterilized dish, *5 cotton seeds*, distilled water. (Control).	12–7–1920	19–7–1920	5	Healthy.
	2	ditto. (Control).	,,	,,	5	Healthy.
COTTON (isolated from Experiment XIII).	3	As in dish No. 1 above, but with *Rhizoctonia* sp.	12–7–1920	19–7–1920	3	Diseased, 2 killed by 20–7–1920.
	4	ditto.	,,	—	0	—
PEAS (isolated from Experiment IV).	5	As in dish No. 1 above, but with *Rhizoctonia* sp.	12–7–1920	19–7–1920	3	Diseased, 1 killed by 20–7–1920.
	6	ditto.	,,	,,	1	Diseased, killed by 20–7–192
BAMIA (isolated from Experiment IV).	7	As in dish No. 1 above, but with *Rhizoctonia* sp.	12–7–1920	—	0	—
	8	ditto.	,,	—	0	—
EARTH NUT (isolated from Experiment IV).	9	As in dish No. 1 above, but with *Rhizoctonia* sp.	12–7–1920	—	0	—
	10	ditto.	,,	—	0	—

EXPERIMENT V (*continued*).

Infections made with *Rhizoctonia* sp. isolated from:—	No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings appeared.	REMARKS.
WATER MELON (isolated from Experiment IV).	11	As in dish No. 1 above, but with *Rhizoctonia* sp.	12-7 1920	—	0	—
	12	ditto.	,,	—	0	—
LUBIA (isolated from Experiment IV).	13	As in dish No. 1 above, but with *Rhizoctonia* sp.	12-7 1920	—	0	—
	14	ditto.	,,	19–7–1920	2	Diseased, killed by 20–7–1920.
MUSTARD (isolated from mustard seedlings attacked in Laboratory garden).	15	As in dish No. 1 above, but with *Rhizoctonia* sp.	12–7–1920	—	0	—
	16	ditto.	,,	—	0	—

The above experiments show that the *Rhizoctonia* sp. which causes sore-shin in Egypt is able to attack seedlings of the following host plants :—

Castor (*Ricinus communis*).
Sesame (*Sesamum*).
Pumpkin (*Cucurbita* sp.).
Lubia (*Vigna sinensis*).
Cabbage (*Brassica oleracea*).
Lucerne (*Medicago sativa*).
Bamia (*Hibiscus esculentus*).
Earth nut (*Arachis hypogaea*).
Water melon (*Citrullus vulgaris*).
Radish (*Raphanus sativus*).
Lettuce (*Lactuca sativa*).
Carrot (*Daucus carota*).
Garden Peas (*Pisum sativum*).

It was also found causing the damping off of cress and mustard seedlings in the laboratory gardens. When this work was in progress diseased adult Haricot Bean plants were received in the laboratory from the Government farm at Gemmeiza. The roots were examined and masses of hyphæ of the same *Rhizoctonia* sp. were found in the tissues. The disease was said to have caused a loss of 50 per cent of the crop on the farm and there is no doubt that the cause was due to this *Rhizoctonia* sp. Some diseased Colocasia plants were found in Gîza and examined. The roots of these plants were also invaded by masses of Rhizoctonia hyphæ. The plants had not been killed but had become stunted and formed no tubers. The plants responded to the fungus attack in the following manner :—

After some of the rootlets had been killed the plant gave rise to adventitious roots from the crown and sometimes even from the bases of the leaf stalks. The plant could not form tubers because, in order to keep itself alive it was forced to expend the energy which it would normally have used for increase in size and formation of tubers in producing adventitious roots.

Adult berseem has also been found attacked and killed by this fungus.

Rhizoctonia sp. in addition to attacking the above host plants when transferred from cotton, is also able to attack cotton when passed back from peas, bamia, earth nut, water melon, lubia and mustard (*see* Experiment V). The fungus was isolated from these six host plants used in Experiment VI for no particular preference and it is very probable that the fungus isolated from any of its hosts would also be able to attack cotton or any other of its hosts. The fungus then is a very general parasite of seedlings and there is no indication

in the above experiments of its being in any way specialized in its parasitism. Wheat, barley and maize were tried and results showed conclusively that they were not attacked by the fungus. Control pots were used as in the above experiments. The experiments on wheat, barley and maize were carefully carried out by Mahmoud Eff. El Dumyati, Technical Assistant of the Botanical Section.

Retention of Parasitism.

With regard to the period during which the fungus can retain its power of infection when propagated saprophytically on media, it is interesting to note that the fungus isolated in the spring of 1920 had been kept growing on media in the laboratory up till the spring of 1922, and on trial it was found that it attacked cotton seedlings quite readily.

Description of the Fungus.

The morphological characters of this fungus vary markedly with the age of the culture and the conditions under which it is grown. It is proposed to describe these differences in detail because by so doing it will be possible to show that this is identically the same fungus as that which Balls (1) and (2) worked with in 1905 and 1906. Further that the two forms of Rhizoctonia in this paper are the same as those described by Shaw (31). In some respects these two fungi resemble each other so closely that Atkinson's description* of this sterile fungus is applicable to both.

(a) *The Mycelium.*—The fungus hyphæ in a culture one or two days old are hyaline, vacuolate, varying in thickness at different points of the same hypha, measuring 5–10μ in diameter, and 100–200μ in length. They branch freely and the branches have a tendency to bend towards the direction of growth of the parent hypha (Plate III, Figs. 1 and 3). All the branches show a characteristic constriction at the base, and the septum separating the protoplasm of the parent hypha from that of the branch is usually about 10–15μ from the main hypha. (Plate II, fig. 2. Plate III, figs. 1–3). A culture

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* *Atkinson's description taken from* (*1*).—"**The freshly developed threads branch freely but not profusely, they are colourless, composed of elongated cells 9μ–11μ in diameter, and 100μ–200μ in length. The branches very near the point of attachment are a little curved towards the point of growth of the same. At the point of attachment with the parent hypha, the branch is considerably smaller than either the diameter of the parent hypha or the main part of the branch, and the septum separating the protoplasm of the greater part of the branch from that of the parent hypha is situated some distance from the latter, usually 15μ to 20μ from the main thread. This portion of the branch the contents of which are continuous with those of the parent, is clavate in form.**"

two days old on potato wedge has sometimes an appearance somewhat resembling dirty whitewash and with very few aerial hyphæ. At other times the same fungus growing on the same medium will produce copious aerial growth which may completely fill the tube up to the plug. The factor which brings about this variation in culture is not yet known. As the hyphæ get older they become first buff colour and then reddish brown ; they are more uniform in thickness measuring in the majority of cases 6μ in diameter; the walls are thicker, more rigid and brittle, breaking off fairly easily at the septa separating the parent hyphæ from the branch hyphæ ; the branches have a tendency to lie more at right angles than in the young hyphæ and do not contain oil globules. (Plate II, fig. 2. Plate III, figs. 1 and 2.)

Again hyphæ are found which are become segmented, by means of septa, into short triangular and barrel-shaped cells (Plate III, fig. 4). These contain numerous oil globules and their diameter ranges from 10–21 μ. When first formed such cells are hyaline and separate easily from one another on being placed in water. All the characters so far described have also been observed in the field and there is no doubt that the short barrel-shaped cells on coming in contact with water serve as a ready means of distributing the fungus through the soil.

(b) *Sclerotia.*—The formation of groups of the short, triangular, and barrel-shaped cells described above is the first step towards the formation of sclerotia. The young developing sclerotia at first have a white fluffy appearance and measure about 1 millimetre in diameter. (Plate IV, figs. 3 and 4). They are formed, in culture, mostly on the surface of the medium and sometimes on the sides of the tubes. The young sclerotia are composed, on the outside, of normal hyaline hyphæ which do not contain oil globules and are in a collapsed state. It is these collapsed hyphæ which give the young sclerotia their whitish, fluffy appearance. The innermost cells are, as stated above, composed of short barrel-shaped cells and after a time turn dark brown in colour.

Balls (1) did not obtain what he could describe as sclerotia but used the term "Resting cells" for what are now known to be the first stages of development of young sclerotia.

As they grow older the sclerotia increase in size, and form a compact mass of dark brown hyphæ (Pseudoparenchyma) (Plate V.) Some of the old sclerotia lose their white fluffy appearance and appear very dark brown in colour (Plate IV, fig. 2) ; others, on the hand, retain their whitish appearance for several months. (Plate IV, figs. 1 and 4.) There is no differentiation into medulla and cortex, the structure being uniform throughout. In a half grown sclerotium the cells near the centre are a deeper brown than those on the outside. The difference in colour is very gradual until the outer hyaline hyphæ

are reached. In old sclerotia this difference in colour is lost and the cells are all of a deep reddish-brown. If kept moist the sclerotia have a texture very much like that of india-rubber, but when allowed to dry they become very hard and are difficult to cut with a razor. Their size in culture on different media vary from 2-15 millimetres in diameter.

In culture in potato wedges sclerotia have been found to coalesce and thus form a compound sclerotial mass closely adhering to the substratum, (Plate IV, figs. 1, and 2). The factors which influence the size ultiately attained by the sclerotia will be discussed later.

No sclerotia have been observed in the field in Egypt. In other countries, however, the formation of sclerotia in the field, both on host plants and in soil seems to be very common. Peltier (29) states that in America "the formation of sclerotia in nature is rather common on many hosts. The best known examples are those formed on the potato tuber. The size and shape of the sclerotia vary considerably. On potatoes they are small, about 1 to 5 millimetres, and are generally flat. On carnation plants they may reach a diameter of 5 to 8 millimetres. When the fungus is grown on soil in pure culture, they become 5 or 6 centimetres in diameter." O'Brien (28) also states that the sclerotia are found on the potato tubers at the end of the growing season in Scotland. Pethybridge (30), working in Ireland, states that the disease on potatoes is " characterized by the presence on the surface of the tuber of very dark, almost black, bodies of irregular shape and varying size which are compacted masses of spawn or mycelium—that is, sclerotia....."

Growth-limiting Factors.

In view of the fact that Balls (1) did not obtain sclerotia in culture and of the variation in size of the sclerotia observed in cultures on different media, some simple experiments were carried out to ascertain the influence of certain factors on the growth of the fungus particularly with regard to the formation of sclerotia. Duggar (14) has also noted these differences and states : " The differences referred to consist in a variable amount of the mealy or tufted growth, or of the amount of aerial growth ; differences in the colour of the colony are also observable, and the rapidity with which sclerotia are formed are all minor distinguishing features. The subject needs further investigation, but in general it is felt that these differences are such as might be due to permanent differences in the pathological strains, on the one hand, or may be regarded as temporary differences due to the recent environment, on the other. The exact conditions under which sclerotia may occur on the various hosts affected have not been determined. It has been noted that affected potato tubers are the main seats of sclerotia formation when the fungus attacks the host."

The results of the experiments described below show that the variation in size of the sclerotia in a single-strain are governed under suitable temperature by the amount of food, moisture, and oxygen, which is available to the fungus. It stands to reason that a fungus cannot possibly produce in any country a sclerotium on a cotton seedling of the size obtained by Peltier (29) on soil, since the weight of these enormous sclerotia is many times that of a cotton seedling. A potato tuber is a much more satisfactory medium for sclerotia formation by the fungus than even the stem of the same plant. In the tuber there is sufficient moisture and food material for the fungus to go on growing for a considerable period. In the case of the stem, once the conducting tissues are destroyed, disintegration sets in fairly rapidly, owing to the activities of saprophytic bacteria and other fungi, thus giving the fungus only a limited time in which to form sclerotia. On the other hand, different strains growing on the same medium and under the same conditions of temperature etc., do show differences in culture which are quite constant.

(*A*) *Aeration.*

Experiment I.—Several cultures were made on both Agar and potato wedges on each successive day for a week. In this way the fungus was obtained in culture at all stages from a day to a week old. The plugs of some of the tubes containing the fungus at different stages of growth were dipped in melted wax so as to hermetically seal the tubes. Others of corresponding stages of growth were left unsealed and allowed to continue growing in the usual manner.

At the end of twenty four hours there was no marked difference between the sealed and unsealed. On the second day the fungus in the sealed tubes had ceased to grow and no further change took place for a fortnight. The fungus in the unsealed tubes continued growing and with some exceptions amongst those on Agar medium, they formed sclerotia. In all cases the sclerotia on potato were larger than those on Agar, and those that failed to form definite sclerotia on Agar got so far as the formation of fluffy aggregations of barrel-shaped cells *i.e.* the resting cells described by Balls (1) (Plate IV, fig. 3). At the end of a fortnight the plugs of the sealed tubes were loosened sufficiently to admit the passage of air into the tubes, and, except for a few which had been sealed when the cultures were but a few hours old, all resumed their growth and formed sclerotia with a few exceptions on Agar as in the unsealed tubes.

The tubes were plugged with absorbent cotton wool because the non-absorbent was not procurable in Egypt. For this reason the Agar medium became dried up in some cases after three or four days. This explains the failure of the fungus to form sclerotia in some of the

tubes containing Agar. As far as available moisture was concerned, therefore, it was more favourable to the fungus in the sealed tubes than the unsealed, since evaporation was impossible. After the absorption, in the first twenty-four hours after sealing, of the oxygen already in the tubes, growth ceased.

Experiment II.—Some milk was placed in two half-litre flasks to a depth of about 2 centimetres. These were then plugged with absorbent cotton wool and sterilized in an autoclave. A large sclerotium was then dropped into the centre of the milk. The plug of one of the flasks was then sealed by pouring on it some melted wax. After four days no sign of growth was seen in either of the flasks. The reason for this was that the large sclerotia on being dropped into the milk sank below the surface and oxygen not being available growth could not take place.

Experiment III.—As in Experiment II except that instead of introducing a large sclerotium into each of the flasks a very small piece of potato on which the fungus was growing was carefully placed on the surface of the milk. Wax was then poured on the plug of one of the flasks.

At the end of forty-eight hours the fungus in both flasks had grown over the whole surface of the milk in a dense white disk. Aerial hyphæ were also present. On the third day, however, growth had ceased in the sealed flasks and no change occurred for one week. No check was observed in the growth of the fungus in the unsealed flask. The hyphæ grew vigorously up the sides of the flask and at one time completely filled it up to the plug. Later some hyphæ turned brown, others collapsed, and small fluffy growths were observed in the upper part of the flask. Near the surface and on the surface of the milk, sclerotia measuring 2–5 millimetres in diameter were formed. The development of the fluffy growths into definite sclerotia was not possible in the upper part of the flask owing to the gradual drying up of the atmosphere above the milk. At the end of the week, the plug of the sealed flask was loosened and growth was immediately resumed by the fungus. This took the same course as that in the unsealed, and sclerotia were formed on and near the surface of the milk.

The above experiments show that the fungus is very sensitive to the presence of oxygen. The fact that sclerotia are always formed on the surface of the media and not in it, is further proof of this.

(*B*) *Moisture.*

As already stated the Agar medium dried up in three or four days in summer owing to the fact that the tubes were plugged with absorbent cotton wool and evaporation was rapid in consequence.

Experiment I.—Some cultures of the fungus were made in tubes containing Agar medium which had been prepared three days previously and which had just commenced to dry up. Other cultures were made in similar tubes containing freshly made Agar medium and with plenty of moisture in the form of drops of water on the sides of the tubes. The fungus grown on the freshly made medium formed sclerotia about 2 millimetres in diameter on the surface of the medium. Those on the medium which had been prepared three days previously only succeeded in forming fluffy growths or a few groups of barrel-shaped cells.

Experiment II.—More than the usual amount of cotton wool was placed at the bottom of large boiling tubes and an excess of water was added. A large trapezium-shaped piece of potato was then placed on the supersaturated cotton wool and the tube plugged with absorbent cotton wool. At first the fungus grew slowly owing to the fact that the piece of potato was very wet. After a few days, however, growth was more rapid and the fungus in one case produced by the end of six weeks a sclerotium measuring 15 millimetres in diameter. (*See* Plate IV, fig. 2.) The conditions of growth in this case were extremely favourable to the fungus, since desiccation was very gradual and food and aeration were plentiful.

Experiment III.—Twelve cultures were made on Agar medium which had been prepared two days previously. The medium was therefore neither very dry nor moist. Six of the tubes were left on the bench in the laboratory whilst the remainder were placed in another room where steps were taken to ensure a moist atmosphere. Those in the laboratory all formed fluffy growths only, whilst five out of the six placed in the other room formed dark brown sclerotia measuring 1–2 millimetres in diameter. The fungus growing on potato formed sclerotia in both rooms.

A culture containing a sclerotium 9 millimetres in diameter was kept in the laboratory during four months in the summer. During this time the sclerotium had become very hard and dry and on being transferred to fresh medium it failed to grow. After some days the sclerotium was soaked in water for twenty-four hours and again transferred on to medium but no fresh growth was obtained from it.

(C) Temperature.

The effect of temperature on the growth of this fungus has been very thoroughly investigated by Balls (1) and (3). He found that growth ceases between 37° C. and 38° C. "The death point was determined with cultures containing small clusters of resting cells, as was also the growth maximum. Tubes of solid culture media

were immersed in a thermo-regulated bath, till they reached its temperature, and were then inoculated while still in the bath, with a small fragment of mycelium free from agar in order to avoid the delay in warming due to the high specific heat of the latter substance. In every case five minutes at 50° C. was fatal to the fungus—no growth supervened after three weeks at the optimum temperature for continued growth, *viz.* 23° C. Five minutes at 48° C. was innocuous in all cases but one, and 49° C. fatal in four cases out of six, so that the death point may be taken as 49° C."

Conditions affecting the Fungus in the Field.

(*a*) *Time of Sowing.*—Generally speaking, cotton sown in February or any time up till about March 15 is badly attacked by Sore-Shin. After this period the amount of Sore-Shin decreases as the season advances up till the middle of April. No observations have been made beyond this date because it is very exceptional that cotton is sown any later, or even as late, as mid-April. There is no doubt, however, that cotton sown at the hottest time of the year would be almost free from Sore-Shin. It is possible, of course, that the temperature at that time is over the optimum for field germination of cotton seed apart from Sore-Shin. The usual date of sowing cotton in the Delta is about the middle of March, although several cultivators sow in February and often, in consequence, are obliged to resow as many as three or four times. In fact, one reason put forward in favour of early sowing in February is that it gives the cultivator time to do his resowing before the season is too far advanced. The fact of the matter is that only a little resowing would be necessary if the sowing date were delayed.

It is doubtful whether the temperature of the seed bed even in dry soil ever reaches, in March, as high as 57° C.—this being the temperature at which growth ceases. On the other hand, the effect of a rise in temperature of the soil before sowing to say 23° C. (*i.e.* the maximum growth temperature) at a depth of 5 centimetres would reduce the moisture content of the soil and gradually dry it up. As previously stated, a large sclerotium kept in the laboratory at a temperature at which growth took place in other tubes failed to germinate at the end of four months owing to desiccation. The temperature of the soil, therefore, can be the optimum for the growth of the fungus and still indirectly cause the death of the fungus by the gradual desiccation of the soil.

A slight rise in temperature has an accelerating effect on the growth of the cotton seedling. Thus cotton sown in February takes twelve days to reach the surface whilst cotton at the middle of March reaches the surface in seven or eight days, thereby decreasing its

period of growth in the danger zone by four or five days. Up till the end of March then, the effect of a rise in temperature reduces the amount of sore-shin, not because of its direct inhibiting effect on the growth of the fungus, but indirectly because of its accelerating effect on the growth of the seedling, and drying up of the upper layer of the soil, which has an inhibiting effect on the growth of the fungus.

(*b*) *Soil.*—The amount of sore-shin depends also to a large extent on the texture of the soil. A heavy clayey loam retains moisture for a much longer period than a lighter soil and a rise in temperature has less effect on the former than the latter. The fungus is therefore able to live in heavy soils under much higher air temperatures than in light soils. Similarly, badly drained land is also more highly infected than well drained land because there is less chance of the soil becoming thoroughly dry.

(*c*) *Cultivation.*—In connection with this disease as with many others caused by soil parasites, good cultivation is absolutely necessary, because if large lumps of soil are allowed to remain, these hold down the weak cotton seedlings and delay for a time, or prevent altogether, the appearance of the seedlings above the soil. The delay exposes the seedlings to the attack of the fungus for a longer period and therefore increases the chances of infection. Apart from the physical resistance to the growing seedlings, large lumps retain moisture and so diminish the desiccating effect which takes place in well cultivated soil.

(*d*) *Rotation.*—The rotations commonly used in Egypt are of two kinds, *viz.*: the two-year and three-year rotations and the crops generally cultivated are as follows :—

Two-year Rotation.	*Three-year Rotation.*
Wheat.	Wheat.
Maize.	Maize.
Temporary Berseem.	Temporary Berseem.
Cotton.	Cotton.
	Permanent Berseem or Beans.
	Fallow.

Thus the cotton crop generally follows berseem. The latter has a bad effect on the tilth and, as has been previously stated, it is itself attacked by the fungus. From the point of view of sore-shin therefore, the fact that cotton follows berseem is bad. This will again be discussed below under " Remedial Measures."

Economic Importance.

The general occurrence of the fungus in the soil throughout the country and its wide host-range are points of special interest in considering the economic importance of this fungus. There are many fungi whose parasitism is highly specialised, that is, they are only able to become parasitic on one species. There are others which are parasitic on some or all the species within a single genus or a single family. The fungus with which we are concerned, however, is able to attack with equal readiness, under favourable conditions seedlings of almost any crop grown in Egypt with the exception of members of the Gramineae. It is evident, therefore, that the fungus causes, when the damage on all its hosts is considered, a financial loss equal to some of the more well-known pests and diseases in Egypt. In the case of cotton, re-sowing is done to fill up the gaps caused by the fungus, but in a good many other crops no re-sowing is done and the gaps remain. If these gaps were filled by healthy seedlings which would develop into adult plants the increase of yield per feddân would be considerable. In view of the large number of crops affected by this fungus it is unnecessary to do more than point out that the control of the fungus by a change in rotation of crops is much more difficult than in the case of a parasite specialised to one host plant. As will be shown below, a great deal can, however, be done in Egypt by careful rotation of crops.

The work on the fungus up to the present has been almost entirely confined to its "damping off "effect on seedlings, but when our knowledge is increased concerning the fungus as a parasite on adult plants its economic importance will be greatly increased.

Identification of the Fungus.

A comparison of the description and plates given in the present paper and of those given by Balls (1) leaves no doubt that this fungus is identically the same as the one Balls described. Further proof of this is given under " Growth-limiting Factors," where it is shown that by controlling certain factors the fungus can be induced to cease growth entirely either after or before it has produced the fluffy growths (resting cells) described by Balls. So far, then, the fungus can be placed in the genus Rhizoctonia of the " Fungi Imperfecti " and to avoid confusion it can be considered for the present as *Rhizoctonia* sp. simply. On further comparison with the descriptions and figures as given by Shaw (32) and Duggar (14 and 15) it became very evident that this species of Rhizoconia is the sterile stage of *Corticium vagum* B and C.

The position with regard to the genus Rhizoctonia has been, in the past, decidedly unsatisfactory and even at the present time it is somewhat confusing. It was very desirable, therefore, to make a further study of the life-history of the fungus in order to make it possible to remove it from the genus Rhizoctonia of the Fungi Imperfecti into the genus to which its fertile stage belongs.

The fertile stage is known both in Europe, India and America. In India (32), the fungus has been found in its fertile stage on Earth nut (*Arachis hypogaea*) and so the writer decided to carry out an experiment in order, if possible, to induce the fungus to produce its fertile stage on the same host in Egypt. For this purpose two small plots (about 2 metres square) of Earth nut were grown side by side in a shady place in the laboratory garden. One plot received a heavy watering from a watering can every morning, whilst the other was watered in the same way both in the morning and again in the evening when the sun had set. When the plants were well up several vigorously growing cultures of the Rhizoctonia sp. were placed at the bases of some of the plants. The earth nut became diseased and a good many of the branches were killed. The fungus formed a dense withish layer of much branched, short hyphæ on the branches and leaf stalks. Some of these were examined daily under the microscope with a view to finding spore formation. No sign of the actual spores were observed for several weeks. In the meantime, however, the gardener had placed alongside the plots some flowerpots containing flowers. These were watered regularly every day but at different times from the watering of the earth nut plots. Some of the overflow from these pots ran down into the earth nut plots so that the soil on one side of the plots was kept continually moist. The fungus grew vigorously over the earth nut leaf stalks and formed a dense white layer on the surface. These were also examined microscopically and on November 8, 1920, spores were found in small numbers. These were in organic connection with typical hyphæ of *Rhizoctonia* sp. so that there was no doubt as to their being formed by this fungus.

The whitish layer was composed of short, closely interwoven, and much branched hyphæ. These hyphæ were in many cases swollen at the tips and by comparison with the basidia-bearing basidiospores they were clearly the first stage in the development of the basidia. The basidiospores were found singly as oval hyaline structures at the tips of two, three, or four finger-like outgrowths (Sterigmata) growing from the end of the short swollen hyphæ (Basidia) described above (Plate II, fig. 3).

No measurements of spores are given here because only a limited number were found, so that detailed study was impossible. The figure of the fertile stage in this paper resembles very closely those figured by Shaw (32) but there is a slight difference between both the Indian

and Egyptian from those given of the American form (15). This, however, may be due to the difference in climatic conditions in the different countries, and to the fact that they were formed on different hosts. The difference between the spore forms in the different countries is no more, if as much, as the difference between the resting cells described by Balls (1) and found by the writer on Agar, and the large sclerotia formed on potato.

It is interesting to note that the fungus did not form spores on earth nut in the summer months and in November the weather was much cooler. Possibly this drop in temperature, combined with the increase in moisture, owing to the overflow of water from the flower pots, brought about conditions which were just sufficiently favourable for the fungus to produce its spore form. Since then a few spores have also been observed on soil attached to the crown of a turnip which had rotted in the field.

So far the fungus has only been found by the writer in its fertile stage when growing as a parasite. In the case of the form on turnip, however, it was not certain whether the fungus was a follower of an insect parasite or not—it was possibly a case of double infection.

Sufficient evidence has been given above to show that this fungus is identical with that described by Balls (1) and Duggar (14 and 15). It has been stated that there are differences between the sclerotia of the Indian and Egyptian forms and the writer has been tempted to give the Egyptian fungus a name which would imply specific identity with other forms from other countries and at the same time indicate that it is a definite strain. This has not been done, however, because the comparative study of the physiology and parasitology of the fungus from different countries has not been carried out under similar conditions.

Dr. Butler has kindly obtained six cultures of the fungus from America, England, India, etc., for the writer's use and these when grown in culture on the same medium show definite characteristics by which they can be recognised one from the other.

It is interesting to note that the sterile form of *Corticium vagum* B and C obtained from Shaw in India, caused sore-shin of cotton seedlings in Egypt. Sterilized sand, sterilized dishes, and distilled water were used as in the above experiments.

To split up a species into varieties, strains, etc., is a dangerous practice without first making a detailed study of all known forms under the same conditions ; on the other hand, it is clear that it would be distinctly unsound, particularly from the economic mycologist's point of view, to keep under the same name members of a single species some of which produce sclerotia and others which do not. Remedial measures against soil fungi must depend largely on local conditions, but if treatment of soil by chemicals or fallow is proved effective

against a form which does not normally form sclerotia it does not follow that the same or a parallel treatment in another country would be effective against sclerotial forms. This would mean much futile contradiction and waste of time by suggesting a line of investigation which could not possibly lead to useful results.

The fungus is identified as *Corticium vagum* B and C with the reservation that the Berkeley and Curtis fungus contains many forms which may have to be separated in the future.

Remedial Measures.

Other workers when dealing with control measures against this fungus emphasize the fact that such measures should have as their main object the destruction of the sclerotia in the soil. This is probably the case in other countries, but in Egypt sclerotia are very rarely formed and, if they are at all, their structure must resemble those of the very young sclerotia in culture alluded to above as "fluffy aggregations of hyphæ." Such young sclerotia cannot stand adverse conditions of moisture, temperature, and humidity to the same extent as the larger compact sclerotia, and it is highly probable that what would destroy the thick-walled brown hyphæ would be more than sufficient to destroy these young and more or less delicate sclerotia.

At the commencement of the work on the control of this fungus it was realized that treatment by sterilizing the soil by means of chemicals or artificial heat is impracticable on a large scale owing to the great difficulty and expense of such an operation. Several experiments have been carried out on a small field scale with the following objects in view :—

(1) To find a method which could be used on a small scale on the Government experimental farms, in cases where it was desired to grow as many plants as possible from seeds of some special varieties. Such a treatment would also be of special value if, for experimental purposes, it were essential to obtain good germination and yet to sow early when the fungus does most damage. Such a method need not, except to a point, be governed by cost of treatment and difficulty of application.

(2) To find another method of control which could be used on a large scale by cultivators and which would, of necessity, have to be cheap and easily applied. It is possible, of course, that a method found suitable for application on a small scale could, with modifications, be used in general practice.

According to Shaw (32), Eriksson's experiments indicated that treatment of the soil with carbolic acid might be used against such a disease and further work by Salmon has confirmed this.

A heavy dressing of lime has proved highly satisfactory as a means of controlling some soil-dwelling parasites. The best known case of this is its use against the Club Root disease of Cabbage, Turnip and other members of the family Cruciferæ.

Evidence in favour of the use of lime against sore-shin has been obtained in pot experiments carried out by the writer at Gîza.

During 1921 and 1922 experiments in the field were carried out both at Gîza and Gemmeiza. Several different chemicals were employed, including those mentioned above, and the results of these experiments will be found in a summarised form in the Second and Third Annual Report of the Cotton Research Board, Egypt (years 1921 and 1922).

The results obtained from some of these trials are not sufficiently important to justify repetition here, but the field tests made to ascertain the effect of liming and of the naphthalene-gypsum seed dressing are described in detail below.

Experiments on Naphthalene.

Balls (1) and (2) has stated that :—

(1) The losses due to the sore-shin fungus can be checked by dressing the seed with naphthalene.

(2) Its use accelerates growth under field conditions, if the percentage used is not too high for the texture (aeration) of the particular soil.

(3) The seed rate can be much reduced when this treatment (*i.e.* as described below) is employed and the seed saved will more than cover the cost of treatment, even when the fungus does no damage whatever.

Experiments were carried out by the writer at Gîza during 1921 and 1922 in order to obtain further information on these points.

Naphthalene Test Experiment I (1921).

A division* containing forty-five ridges of ten holes each was divided into small blocks sown on the scatter principle with :—

(*a*) Untreated seed.
(*b*) Seed treated with 1 per cent naphthalene and 5 per cent gypsum.
(*c*) „ „ 2 „ „ „ 5 „ „
(*d*) „ „ 3 „ „ „ 5 „ „

Exactly 12 seeds per hole were sown in each case.

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* A "division" is a strip of land lying between two adjacent water channels in a field laid out for irrigation. The water channels run approximately parallel to each other and at right angles to the ridges on which the cotton is sown. The water channels are dry except when irrigation is in progress.

(i) *Naphthalene Dressing 1 per cent.*—Two grams of naphthalene was added to 10 grams of gypsum and both ground up together in a mortar. 200 grams of seed were then added and mixed with naphthalene-gypsum mixture. Water was then added to wet the seed and dressing thoroughly, the process of mixing with the hands being again repeated thoroughly for several minutes until the dressing was evenly distributed over the seed. The seed was then spread out in a thin layer on a sheet of paper, placed in the sun to dry, and sown almost immediately afterwards.

(ii) *Naphthalene Dressing 2 per cent.*—Treatment as above but in following proportion :—

Weight of	seed	200	grammes.
„	naphthalene ...	4	„
„	gypsum	10	„

(iii) *Naphthalene Dressing 3 per cent.*—Proportion used :—

Weight of	seed	200	grammes.
„	naphthalene ...	6	„
„	gypsum	10	„

The seed was treated, sown, and watered on April 4. All seedlings were counted on April 13 when the seedlings were well up in all ridges including controls. No marked difference was observed between the time of appearance of the seedlings above the soil. If anything, the 2 and 3 per cent were slightly behind the control and the 1 per cent.

RESULTS.

Ridges.	Treatment.	Total No. of Seeds sown.	No. of Seedlings which appeared above Soil.	Percentage of Seedlings which appeared above Soil.	Standard Deviation.
1– 3					
13–14	Control.	1,080	852	78·6	3·7
24–25					
35–36					
4– 6					
15–17	1 per cent	1,440	1,132	78·6	5·8
26–28					
37–39					
7– 9					
18–20	2 per cent	1,440	1,071	74·5	2·4
29–31					
40–42					
10–12					
21–23	3 per cent	1,440	956	66·4	6·1
32–34					
43–45					

Naphthalene Test Experiment II. (1922).

Four consecutive divisions comprising 65 ridges of 4 metres width were sown as follows :-

The whole of Division I, and the northern 11 ridges and the southern 10 ridges of Divisions II, III, and IV were sown in the usual manner and served as belts. The remaining 44 ridges of Divisions II, III and IV were sown as follows :—

Ridge 12 with untreated seed.
,, 13 ,, seed treated with 1 per cent. naphthalene dressing.
,, 14 ,, seed treated with 2 per cent. naphthalene dressing.
,, 15 ,, seed treated with 3 per cent. naphthalene dressing.

} 10 holes per ridge and exactly 12 seeds per hole.

and so on, making in all eleven repetitions of each kind.

The seed (Sakel J/20) was treated, sown, and watered on 23–2–1922 and the majority of the seedlings appeared above the soil on 11-3-1922, *i.e.* seventeen days after sowing. The counting of the number of seedlings in all holes was not made until the 28–3–1922 because at this early date the growth of the seedlings was somewhat slow.

In the following table the results are given for the controls and treated in the same order as they were in the field, *i.e.* from the north to south. All holes with less than two seedlings were considered as blanks.

Controls.		1 per cent Naphthalene.		2 per cent Naphthalene.		3 per cent Naphthalene.	
No. of Blanks.	Total Number of Seedlings.	No. of Blanks.	Total Number of Seedlings.	No. of Blanks.	Total Number of Seedlings.	No. of Blanks.	Total Number of Seedlings.
12	62	13	47	15	46	12	56
22	19	27	4	15	51	15	56
25	23	25	16	14	39	12	63
24	21	19	46	16	63	9	93
13	69	14	52	16	51	9	68
21	25	19	57	21	31	4	110
13	65	15	37	9	71	10	75
18	44	16	29	15	44	13	71
16	41	9	90	18	51	3	98
14	56	9	84	9	83	7	114
19	32	6	94	9	62	3	120
197	417	172	546	157	592	97	924

The result shows a distinct improvement in favour of the ridges treated with the naphthalene-gypsum dressing. The tilth was very bad and there is no doubt that with good cultivation the germination throughout the experiment would have been much better. A good many seedlings had been killed off by cutworm and mole cricket.

It is impossible to state the causes of death of each individual seedling, since these often overlap. There is no doubt, however, that the naphthalene dressing did check sore-shin in this experiment, because the divisions were examined each day near the time of appearance of seedlings above the soil to see whether there was any difference between the time of appearance of the seedlings in the treated and control. No such difference was observed but it was obvious at a glance that the 3 per cent naphthalene was the best of all in numbers of seedlings.

The good results obtained in the above experiment as compared with the 1921 experiment led the writer to make further tests.

Naphthalene Test Experiment III. (*1922*).

This experiment was carried out on Divisions V and VI adjoining on the west side Division IV in the above experiment. This time, however, only the 2 per cent and the 3 per cent, naphthalene dressings were tried. In Divisions V and VI the northern 7 ridges and the southern 13 ridges were sown as belts. This left 45 ridges in each division for the experiment. In Division V five ridges of seed treated with 2 per cent, naphthalene and 5 per cent, gypsum were sown next to the belt on the north, and followed by 5 ridges of 3 per cent. naphthalene dressed seed, and then by 5 ridges of untreated seed and so on for three repetitions. In Division VI the same method was carried out except that on the north it commenced with 5 ridges of untreated (control), followed by 5 ridges of 2 per cent, naphthalene and 3 per cent, napthalene respectively and so on for three repetitions. Thus the experiment comprised 30 ridges of each treatment laid out in blocks of 5 ridges on the scatter principle. Ten holes were sown in each ridge and exactly 12 seeds per hole.

The seed used was the same kind as in Test Experiment II, *i.e.* Sakel J/20. Treated, sown and watered on March 13, 1922. The seedlings were counted on April 1, 1922. Tilth good.

The following plan diagram gives the results of the counting of seedlings :—

Division VI.			Division V.		
Treatment.	No. of Blanks.	No. of Seedlings.	Treatment.	No. of Blanks.	No. of Seedlings.
C.	1	314	N. 2 per cent	6	268
N. 2 per cent	12	236	N. 3 per cent	2	275
N. 3 per cent	9	185	C.	15	269
C.	13	230	N. 2 per cent	4	220
N. 2 per cent	20	142	N. 3 per cent	12	180
N. 3 per cent	9	204	C.	16	187
C.	10	215	N. 2 per cent	10	197
N. 2 per cent	11	196	N. 3 per cent	1	284
N. 3 per cent	11	193	C.	12	247

Total Estimation of Seedlings and Blanks.

Controls.		N 2 per cent.		N 3 per cent.	
No. of Blanks.	No. of Seedlings.	No. of Blanks.	No. of Seedlings.	No. of Blanks.	No. of Seedlings.
67	1,462	63	1,259	44	1,321

The treatment was carried out as for the previous experiment. The result shows no marked difference between treated and untreated.

Naphthalene Test Experiment IV (1922).

Small plots of different varieties of cotton were being sown on the Gîza Experimental Farm for experimental purposes. Use was made of these to make a further test. This was done as follows :

Three kilogrammes of each of the following varieties of seed were weighed out and treated with 2½ per cent dressing of naphthalene and 5 per cent gypsum :—

Sakel J/20, Assîli G/20, and Ashmûni B/21.
Weight of seed 3 kilos.
„ „ naphthalene 75 grammes (*i.e.* 2½ per cent of 3 kilos).
„ „ gypsum 150 grammes (*i.e.* 5 per cent of 3 kilos).

The seed was treated on 15–3–1922 and treated and untreated sown and watered on 16–3–1922. The treatment of the seed was carried out on the floor of the laboratory, which is made of concrete, so that there was a minimum loss of dressing during the process. The seed was then spread out in a thin layer to dry. The plots in which the different varieties were sown were a considerable distance from each other.

Sakel J/20.—The plot comprised twenty-eight ridges each of thirty-one holes. The first two ridges were sown with the treated, and the second two ridges with the untreated seed and so on alternately, every two ridges with treated and untreated. The plot was sown as nearly as possible with the same number of seeds per hole without actual counting. The number of holes with two or more seedlings were counted on 28–3–1922. Those with less than two seedlings in a hole were considered as blanks.

RESULTS.

No. of Ridge.	Treated or Untreated.	No. of Holes with 2 or more Seedlings.	Total No. of Holes with 2 or more Seedlings
1	Treated.	13	
2	,,	23	
3	Untreated.	19	
4	,,	26	
5	Treated.	21	
6	,,	24	
7	Untreated.	18	
8	,,	13	
9	Treated.	19	
10	,,	21	
11	Untreated.	22	
12	,,	10	
13	Treated.	13	In treated ridges 255.
14	,,	20	
15	Untreated.	17	In untreated ridges 254.
16	,,	15	
17	Treated.	12	
18	,,	20	
19	Untreated.	20	
20	,,	11	
21	Treated.	13	
22	,,	17	
23	Untreated.	20	
24	,,	19	
25	Treated.	20	
26	,,	19	
27	Untreated.	26	
28	,,	18	

Assili G/20.—This plot comprised thirty ridges of thirty-eight holes each. Sown as above but with first two ridges untreated, followed by two ridges of treated and so on. Holes counted on 28–3–1922.

RESULTS.

No. of Ridge.	Treated or Untreated.	No. of Holes with 2 or more Seedlings.	Average No. of Holes with 2 or more Seedlings per Ridge.
1	Untreated.	26	
2	,,	38	
3	Treated.	34	
4	,,	25	
5	Untreated.	34	
6	,,	33	
7	Treated.	21	
8	,,	14	
9	Untreated.	10	
10	,,	10	
11	Treated.	13	
12	,,	14	
13	Untreated.	14	
14	,,	15	
15	Treated.	18	Treated 22·3.
16	,,	21	Untreated 23·9.
17	Untreated.	15	
18	,,	34	
19	Treated.	29	
20	,,	25	
21	Untreated.	21	
22	,,	28	
23	Treated.	24	
24	,,	24	
25	Untreated.	23	
26	,,	28	
27	Treated.	26	
28	,,	25	
29	Untreated.	23	
30	,,	30	

Ashmûni B/20.—Number of ridges 32. Number of holes per ridge 35.

RESULT.

No. of Ridge.	Treated or Untreated.	No. of Holes with 2 or more Seedlings.	Total No. of Holes with 2 or more Seedlings.
1	Treated.	29	
2	,,	35	
3	Untreated.	30	
4	,,	27	
5	Treated.	31	
6	,,	35	
7	Untreated.	31	
8	,,	30	
9	Treated.	33	
10	,,	35	
11	Untreated.	32	
12	,,	34	
13	Treated.	35	
14	,,	34	
15	Untreated.	31	
16	,,	32	Treated 521.
17	Treated.	31	
18	,,	30	Untreated 501.
19	Untreated.	30	
20	,,	31	
21	Treated.	34	
22	,,	29	
23	Untreated.	32	
24	,,	35	
25	Treated.	29	
26	,,	33	
27	Untreated.	28	
28	,,	34	
29	Treated.	33	
30	,,	35	
31	Untreated.	29	
32	,,	35	

General Deductions from Experiments with Naphthalene.—With the exception of Experiment II, the above test experiments show that the dressing of cotton seed with naphthalene and gypsum did neither good nor harm. In the case of Test Experiment II the soil texture was bad and the seed was sown early so that the amount of sore-shin present was greater than in the other experiments. As can be seen from the results, there was, however, sufficient soreshin in the Test Experiments III and IV for the naphthalene to work on.

Temperature seems to have no effect on the treatment itself because Balls' Giza trial was carried out in the first week in March 1906, and his Mit el Diba trials were sown on March 30, 1906, that is, over a fortnight later than Test Experiment III, 1922.

There is no doubt that naphthalene vapour can check the growth of this particular fungus, because a small flake introduced into a large tube containing an actively growing culture causes growth to cease almost immediately. It is interesting to note that naphthalene has no effect whatever on the growth of some other fungi, *e.g.* Fusarium, Penicillium, Aspergillus, etc.

The question which naturally arises with regard to this treatment is the explanation of its success in some cases and its failure in others. It has already been stated that in such experiments it is impossible to estimate the loss caused by "Sore-Shin" apart from loss caused by lumps of soil which hold down seedlings, and the loss caused by insects and various other factors. It is true that Balls gives separate figures showing the resowing done in his Giza trial on account of the fungus and on account of the texture of the soil. These two factors must overlap in a large number of cases. In the absence of the fungus a great many seedlings would manage, after a certain delay, to reach the surface in spite of lumps of soil, but in the presence of the fungus the delay caused by the lumps of soil gives sufficient time for the fungus to kill the seedlings.

There is a similarity between Balls' results and those in the above experiments in that the best results were obtained only when the soil texture was bad. In the case of the Giza trial 1906 it was definitely stated that the tilth was very bad in one case and bad in the other. In the Mit el Diba trials 1906 the tilth was better and the results were not so good. It seems, therefore, that when the tilth is bad the naphthalene does protect the seedlings against "Sore-Shin."

The influence of good cultivation of the soil, with regard to its effect on the value of the naphthalene seed dressings, is not a simple and straightforward one on the fungus only but it also affects the dressing itself and insects. In the case of well cultivated soil the amount of fungus will be diminished considerably owing to its exposure to the sun and air, and consequent desiccation. The effect of the dressing then would be more marked in badly cultivated soil since there would be more fungus present for it to act on. On the other hand there is in the case of well cultivated soil a freer passage of air and exchange of gases to and from the atmosphere in the upper layers of the soil. Thus it follows that badly cultivated land will retain the naphthalene vapour much more than well prepared land and so have more effect on the fungus.

Good cultivation has a similar effect on the insect life (cut worm and mole cricket) to that which it has on the fungus. The number

of insects is reduced and the loss of naphthalene vapour into the air lessens the effect of the dressing as an insectifuge. According to Bourcart (6), naphthalene is used against the mole cricket (*Gryllotalpa vulgaris*). "To drive it off it suffices to bury a little naphthalene in the ground as it is being tilled." It is also used against various other types of insects. It is noteworthy, with regard to this insect, that as the season advances and gets hotter it, like the fungus, does less damage. It seems, therefore, that Balls' naphthalene seed dressing does lessen the amount of damage caused by sore-shin, and by insects, but only under certain conditions of soil texture. As a treatment to be used universally it cannot be recommended because the conditions under which it would prove beneficial are mainly brought about by bad farming. Furthermore, in contradiction to Balls, the treatment of cotton seed with napthalene seed dressing does not increase or stimulate field germination of cotton seeds (*vide* above experiments). This is also shown in the following table extracted from Bourcart (6).

Table showing Action of Naphthalene on Germination Capacity of Cotton Seed (Bourcart).

	Percentage of Germination.	
	Seed covered with Cotton.	Seed without Cotton.
Untreated	86	91
Treated with naphthalene 8 days ...	87	91
,, ,, ,, 14 ,, ...	91	90
,, ,, ,, 3 ,, ...	87	88

"Sore-Shin" Liming Experiment, Gîza (1922).

An experiment was carried out at Gîza to ascertain the effect on sore-shin of a heavy dressing of slaked lime by improving the tilth.

Lay-out of Plot.—An almost square plot of about $2\frac{1}{2}$ feddans was used, the outside portion being sown as a wide protective belt and the inner portion divided into 42 small rectangular beds, each of which was 85 square metres in area.

Application of Lime.—The ridges were first made by a plough only. 220 kilogrammes of slaked lime were then applied on January 25, 1922, to half the number of beds in chequer-plot fashion.

The lime was worked into the soil by breaking down the ridges with a fass and remaking.

The untreated beds received the same cultivation except for the application of lime.

Sowing.—Sowing was done by the wet method (*i.e.* with previously soaked seed). The land had been watered in preparation on February 14. Seed used was Ashmûni (D/21). Rate of sowing as nearly as possible 12 seeds per hole. Date of sowing February 25, 1922. It was observed at the time of sowing that the soil in the limed beds was drier on the surface than in the untreated beds.

Records.—When the seedlings were well up and the first leaves had formed, the number of holes with less than two seedlings were counted throughout the plot, all such holes being recorded as "blanks."

Result.

No. of Bed.	Treated or Untreated.	No. of Blanks.	No. of Bed.	Treated or Untreated.	No. of Blanks.
1	Limed.	80	22	Unlimed.	99
2	Unlimed.	39	23	Limed.	63
3	Limed.	48	24	Unlimed.	52
4	Unlimed.	42	25	Limed.	21
5	Limed.	39	26	Unlimed.	9
6	Unlimed.	126	27	Limed.	54
7	Limed.	148	28	Unlimed.	98
8	Unlimed.	95	29	Limed.	131
9	Limed.	71	30	Unlimed.	121
10	Unlimed.	67	31	Limed.	61
11	Limed.	48	32	Unlimed.	33
12	Unlimed.	38	33	Limed.	16
13	Limed.	115	34	Unlimed.	146
14	Unlimed.	148	35	Limed.	154
15	Limed.	100	36	Unlimed.	112
16	Unlimed.	102	37	Limed.	87
17	Limed.	51	38	Unlimed.	44
18	Unlimed.	53	39	Limed.	27
19	Limed.	37	40	Unlimed.	33
20	Unlimed.	73	41	Limed.	123
21	Limed.	165	42	Unlimed.	133

Total result ... ... { Limed 1,639
Unlimed 1,663

The result shows that the treatment as carried out in the above experiment was of no value against sore-shin, even though the sowing date was exceptionally early for the district.

It is of interest to note, in passing, that the final yields of the different beds were taken very carefully, but that no difference in yield appeared between treated and untreated land.

General Recommendations.

So far it will be seen that none of the various treatments which have been experimented with here can be recommended for general application.

Certain general recommendations can however be made in the light of experience gained.

(*a*) *Cultivation.*—After what has already been said, the effects of good cultivation with regard to this disease need only be given under headings as follows :—

(*a*) Maximum desiccation.
(*b*) Maximum soil temperature.
(*c*) No danger from large lumps of soil.

The earlier the soil is cultivated the greater the desiccation and rise in temperature. When the land has been thoroughly tilled it should be ridged up by plough only, and left as late as possible before finally making up the ridges with the fass. In this manner the top of the ridge made by the plough will be exposed to the sun and will form the seed bed when the seed is sown after the ridges are finally made up. This is true for all types of soil and is of immense value on salty lands where the "wet method" of sowing is used, provided the following operation is also carried out. When the water has settled down a "zahafa" should be passed over the ridges to remove the soil on the top with contains a great amount of salt. The seed should then be sown on top of the "zahafaed" ridge. Thus the salt will be removed and the soil which was previously exposed to the sun, and therefore partially sterilized, will form the seed bed. This method is also used with success on heavy lands which do not necessarily contain much salt but where if the "dry method" of sowing is used the heavy soil cakes and binds itself together, thus giving great assistance to the "Sore-Shin" fungus.

(*b*) *Time of Sowing.*—No hard and fast rule can be made in regard to the best time in which to sow. There is a considerable variation in temperature in the spring in different years, and what is the optimum date in one province is not necessarily the optimum in another. Provided germination is satisfactory, early sown cotton will ripen early, thereby escaping much of the loss which late sown cotton suffers from the pink boll worm. On the other hand cotton sown early may give a very poor stand of seedlings on account of sore-shin and if the weather is unfavourable resowing may have to be done as much as three or four times. The result is an uneven crop which will ripen unevenly.

Generally speaking if cotton is to follow temporary berseem it is not advisable to sow in Middle Egypt before the March 15, when

the weather is usually bright and sunny and germination is good. Cultivators who own large estates may object to this on the grounds that if sowing is only commenced on March 15 the last sown will be very late. In order to overcome this difficulty it is suggested that the seed be placed in the soil and left unwatered. Provided the soil is dry it will come to no harm. This can safely be done on the Government experimental farms and large estates when watering can be done at short notice. It is not safe to do it otherwise because a shower of rain would cause the seeds to germinate and subsequent evaporation cause their death.

(*c*) *Depth of Sowing.*—The seeds should not be sown too deeply because the seedlings take longer to reach the surface thereby giving the fungus sufficient time to kill off a large percentage. Further, even in the absence of sore-shin many seedlings fail to reach the surface when sown deeply, because they are held under by the soil.

(*d*) *Position on Ridge.*—If the sowing is done low down on the ridge the amount of sore-shin is greater because there is more moisture and the soil becomes caked thus delaying the appearance of the seedlings above the soil. It can be easily arranged to sow at a level just above that reached by the irrigation water.

(*e*) *Rotation of Crops.*—It has already been pointed out that cotton follows temporary berseem in the two and three-year rotations generally followed in Egypt.

At the outset, however, the writer wishes to point out that in the following rotations there is nothing suggested which is not already in practice in some parts of the country. Moroever, it is fully realised that berseem as a crop is all important in Egypt, since it is the staple fodder for all live stock. For this reason care is taken not to make any sweeping statements, since each individual farmer, particularly the small cultivators, has his financial and other difficulties to contend with. It is possible, indeed highly probable, that the Fellaheen realise that a period of sharaqi (fallow) will benefit the land, but if they state that they have not the capital on which to live during that period of sharaqi they put forward an argument which cannot possibly be refuted. Here suggestions only are made, and the reasons for those suggestions given, at the same time realising that for small cultivators they are impracticable. Indeed, it can be safely added that with the present system of small holdings really sound methods of agriculture are impossible. On ezbas (farms) of a hundred feddans to dairas (estates) of two or more thousand feddans a great deal can be done to control "Sore-Shin." By the same operations cultivators can improve the yield of cotton apart from the disease. The following table diagrams show the time and order in which the different crops follow one another in the two and three-year rotations.

Two Years Rotations.

Month of the Year.	Rotation "A."		Rotation "B."		Rotation "C."	
	Crop on one half of Land.	Crop on other half of Land.	Crop on one half of Land.	Crop on other half of Land.	Crop on one half of Land.	Crop on other half of Land.
October	—	—	—	—	—	—
November	Wheat	Temp. Berseem	Wheat	Fallow. Temp. B.	Perm. B. Wheat.	Temp. Berseem.
December	—	—	—	— —	— —	—
January	—	—	—	— —	— —	—
February...	—	—	—	— —	— —	—
March	—	Cotton	—	Cotton —	— —	Cotton
April	—	—	—	— Cotton	— —	—
May	—	—	—	— —	— —	—
June	—	—	—	— —	— —	—
July	Maize	—	Maize	— —	Maize	—
August	—	—	—	— —	—	—
September	—	—	—	— —	—	—
October	—	—	—	— —	—	—
November	Temp. Berseem	Wheat	—	Wheat	Temp. Berseem.	Perm. B. Wheat
December	—	—	Fallow. Temp. B.	—	—	— —
January	—	—	— —	—	—	— —
February...	—	—	— —	—	—	— —
March	Cotton	—	Cotton —	—	Cotton	— —
April	—	—	— Cotton	—	—	— —
May	—	—	— —	—	—	— —
June	—	—	— —	—	—	— —
July	—	Maize	— —	Maize	—	Maize
August	—	—	— —	—	—	—
September	—	—	— —	—	—	—

Three-Year Rotations.

Month of the Year.	Rotation "D."			Rotation "E."		
	Crop on First Third of Land.	Crop on Second Third of Land.	Crop on Third Third of Land.	Crop on First Third of Land.	Crop of Second Third of Land.	Crop on Third Third of Land.
Oct.	—	—	—	—	—	—
Nov.	Wheat	—	Perm. B.	Wheat	Temp. B.	Perm. B.
Dec.	—	—	—	—	—	—
Jan.	—	—	—	—	—	—
Feb.	—	Cotton	—	—	—	—
March	—	—	—	—	Cotton	—
April	—	—	—	—	—	—
May	—	—	—	—	—	—
June	—	—	—	—	—	—
July	Maize	—	—	Maize	—	—
Aug.	—	—	—	—	—	—
Sept.	—	—	—	—	—	—
Oct.	—	—	—	—	—	—
Nov.	Perm. B.	Wheat	—	Temp. B.	Perm. B.	Wheat
Dec.	—	—	—	—	—	—
Jan.	—	—	—	—	—	—
Feb.	—	—	Cotton	—	—	—
March	—	—	—	Cotton	—	—
April	—	—	—	—	—	—
May	—	—	—	—	—	—
June	—	—	—	—	—	—
July	—	Maize	—	—	—	Maize
Aug.	—	—	—	—	—	—
Sept.	—	—	—	—	—	—
Oct.	—	—	—	—	—	—
Nov.	—	Perm. B.	Wheat	Perm. B.	Wheat.	Temp. B.
Dec.	—	—	—	—	—	—
Jan.	—	—	—	—	—	—
Feb.	Cotton	—	—	—	—	—
March	—	—	—	—	—	Cotton
April	—	—	—	—	—	—
May	—	—	—	—	—	—
June	—	—	—	—	—	—
July	—	—	Maize	—	Maize	—
Aug.	—	—	—	—	—	—
Sept.	—	—	—	—	—	—

Rotation "A."—The table shows that the cotton crop regularly follows the temporary berseem. In general practice this means that the cotton is not sown until fairly late in March and even so the cultivation of the land is incomplete and hurried. Since berseem is itself one of the host plants of the fungus it follows that there will be more fungus in the soil after it than before it. Hurried cultivation results in bad tilth and low temperatures of the soil, both of which factors are advantageous to the fungus and disadvantageous to the cotton seedling as has already been pointed out. Moreover, the fact that berseem is a leguminous crop, and the cattle whilst being pegged out for grazing trample down the soil into a hard compact mass, makes the tilth very bad and the land difficult to cultivate. The fact that the cotton is not sown until the end of March does help the cotton slightly since at this time it is usually fairly warm. In spite of the sun's aid, however, the stand of seedlings is usually bad. Berseem also encourages cut-worm, which causes damage to cotton seedlings.

Rotation "B."—This is a considerably better rotation from the point of view of the cotton crop. Half the land that is going to be under cotton has been left bare fallow from October until the latter half of February, whilst the other half has been under temporary berseem as in Rotation "A." It is obvious that the land going under cotton after the bare fallow can be thoroughly cultivated during the winter and the upper layers of the soil thoroughly desiccated. The cotton can be sown early before the temporary berseem is ploughed in so that the area under temporary berseen can be more thoroughly cultivated than in Rotation "A," since only half the area has to be dealt with. With regard to the portion under cotton after bare fallow it should also be pointed out that before the bare fallow the crop was maize and preceding maize was a short summer fallow and wheat. Wheat and maize are not attacked by the fungus and the summer fallow in between raises the temperature of the upper layers of soil sufficiently to kill the fungus. If, as advocated by Messrs. McKenzie Taylor and Chamley Burns, the land under summer sharaqi is ploughed and cross-ploughed, the effect on the fungus will undoubtedly be very considerably increased. The amount of land to be placed under temporary berseem must, of course, be judged by each cultivator, since he knows best what his requirements are for fodder. From the point of view of cotton, however, the less sown the better. If he can manage with only a third of the area which was previously under maize instead of half, so much the better for the cotton crop.

Rotation "C."—As in the case of Rotation "A," all the land under cotton was previously under temporary berseem. There is

one essential point of difference between Rotations "A" and "C," since in the latter when one half is under temporary berseem the other half is under permanent berseem and wheat. The cotton crop would be considerably better both in stand of seedlings and in yield if the temporary berseem were replaced by winter fallow. If this reduces fodder too much there are still the following two possibilities:—

(i) To increase the area under permanent berseem and reduce that under wheat.

(ii) If the available berseem is not sufficient after reducing the wheat to a minimum then put as little as possible of the land for cotton under temporary berseem, leaving the remainder bare fallow.

Rotation "D."—This is the rotation practised on large farms on land which is considered to be better cotton land than wheat land; in districts which are thinly populated and, in consequence, where the amount of labour available is limited; on salty lands, since it is possible to give the land a washing at flood time. This watering is known as "Taneel." From the point of view of the cotton crop, both as regards yield and sore-shin, this is the best of all. Although the preceding crop is permanent berseem, this is more than compensated by the fact that there comes between the berseem and cotton a period of *sharaqi* extending over eight months. These eight months *sharaqi* are of great value in killing the fungus in the soil, since it occurs during the hot summer months. The previous remarks with regard to ploughing and cross ploughing are also applicable to this case. A comparison on the same land has been made by a cultivator in Qalyubîya Province between cotton after this long sharaqi and after temporary berseem, after beans, and after maize and winter bare fallow. The best germination and the biggest yield was obtained after the long bare fallow. The second best was after maize and bare fallow and the worst after beans and temporary berseem. Between the last two there was no difference. Beans and temporary berseem have two points in common, *viz.*: both are leguminous crops and both are host plants of the fungus causing sore-shin.

Rotation "E."—This is the rotation which is generally followed on land which is considered to be better wheat land than cotton land and in districts where labour is plentiful. As regards sore-shin this rotation takes a position between Rotations "A" and "C." The cotton always follows berseem as in "A" and "C" and some of the land is under permanent berseem as in "C." The modifications possible for benefiting the cotton crop, and suggested under Rotations "B" and "C" only partially hold good in this case. It has

already been stated that this is good wheat land so that it is obviously undesirable to reduce the area under that crop. If possible replace temporary berseem by bare fallow and depend for fodder on the area under permanent berseem. If this is not satisfactory, put as little as possible of the area going under cotton under temporary berseem in the manner of Rotation "B."

(*f*) *Drainage.*—It has already been stated that badly drained land is more highly infected than well drained land. There are a great many agriculturists in Egypt who state that the drainage of the Nile Delta is essential for the maintenance of the yield of crops. It is not out of place to state here that there is considerable evidence to support this view if the pathological aspect of the question be considered as apart from the physiological effect of rise in the water table, etc. There are a considerable number of serious diseases in badly drained land in Lower Egypt which are of little or no economic importance in Upper Egypt where perennial irrigation is also used, and which are less serious on well drained land in the Delta. A very good example of this is the rusts of wheat. South of Minya, wheat rusts cease to be of any economic importance, but from Minya northwards there is a gradual increase in the rust attacks. Temperature may have a little to do with this, but not very much, since at Beni Suef it is possible to find very badly rusted wheat on badly drained and salty lands and almost clean and better wheat on well drained lands. It is realised that methods of cultivation and manuring play an important part with regard to rust attacks, but the difference is too constant, and has been observed throughout the whole country, for it to be due to anything else.

The same thing has been observed with regard to the "Die-back" and "Gummosis" of citrus trees. Those in badly drained-land suffer very badly from both diseases whilst those on well drained land suffer very little. This is quite apart from the kind of stock used (*see* under *"Citrus gummosis"*).

In addition to the above diseases several others, including mildews in different plants, gummosis of stone fruits, and (to cite one example *of an insect pest*) aphides, are far more serious on badly drained land than on land where there is an adequate system of draining away the water. Moreover, there would be no such thing as salted lands. At no distant date Egypt will be obliged seriously to consider an extensive and efficient method of draining the whole of the Delta.

Root-rot of Cotton, Loubia, and Phaseolus.

At the beginning of July 1920, a form of *Rhizoctonia* which differed very considerably from the sterile stage of *Corticium vagum* B and C was found causing a root-rot of loubia (*Vigna sinensis*) in the garden of the Horticultural Section, Gîza. A few weeks later the same fungus was also found causing a similar disease of beans (*Phaseolus vulgaris*) in the same garden. Later still this fungus was isolated from the roots of adult cotton plants which had died from a form of wilt disease on the Experimental Farm of the Botanical Section, Gîza.

Although it was quite evident that the fungus found on loubia was morphologically similar to that on Phaseolus, it was decided to treat them as two distinct fungi since they might, on trial, differ in their parasitism and thus prove to be biological species or strains of the same botanical species.

Infection experiments were carried out on the same lines as those previously described under "Sore-Shin." Sterilized dishes, sterilized sand, and distilled water were used. The fungus was placed with the seed in the sand in the case of the infected dishes, and controls without fungus were kept throughout. The fungus was isolated two or three times from experimentally infected plants and again used for further infection experiments. The host plants on which the fungus from both loubia and Phaseolus was tried included :—

Loubia (*Vigna sinensis*).
Beans (*Phaseolus vulgaris*) white and green varieties.
Bamia (*Hibiscus esculentus*).
Garden Peas (*Pisum sativum*).
Pumpkin (*Cucurbita Pepo*).
Cotton (*Gossypium* sp.)
Earth nut (*Arachis hypogaea*).

Similar experiments on cotton only were also carried out with the fungus isolated from the roots of wilted adult cotton plants. Unfortunately, the detailed records of the experiments carried out with the fungus in 1920 have been lost and therefore only a summary of the results can be given here. The parasitism of the fungus from loubia and Phaseolus was exactly similar. It was found to attack both the white and green varieties of Phaseolus mostly, and to a slightly less extent seedlings of loubia. Moroever, it attacked bamia seedlings to a less extent than either Phaseolus or loubia, and only very slightly attacked the cotyledons of garden peas. None of the other hosts, including cotton seedlings were attacked by the fungus isolated from loubia, phaseolus, and adult cotton plants.

The upper portions of the diseased loubia and phaseolus plants examined in 1920 were found to have turned brown and withered. They could be easily removed from the soil owing to the fact that the rootlets had been destroyed. The bark peeled off very readily and the woody portion of the roots had dried up and broken down into fibrous shreds which could be easily crumpled between the fingers. The bast seemed to have been completely destroyed. On the inside of the bark and on the surface of the wood were found hundreds of tiny, black, spherical bodies which proved on further examination to be the sclerotia of the fungus. Transverse and longitudinal sections of the roots showed the presence of numerous sclerotia and hyphæ in the vessels and parenchymatous tissue (Plate VII, figs. 1 and 2).

Description of the Fungus.

As in the case of *Corticium vagum* B and C the morphological characters of the mycelium of this fungus vary with the age of the culture. The fungus produces more aerial hyphæ on potato wedge than on prune agar. Sub-cultures on both media appear whitish for the first few days but later they turn black owing to the formation of numerous sclerotia embedded in the substratum and to the hyphæ turning blackish with age (Plate VI, figs. 1 and 2). Sometimes the fungus produces on potato wedges, particularly where the medium is pressed to the side of the tube, a reddish purple colouration which later deepens into a beautiful deep violet colour. This character, however, is not constant and has only been observed in some tubes containing cultures of the fungus recently isolated from its host plant.

Microscopic examination of the hyphæ in a sub-culture one or two days old shows that they are hyaline and abundantly branched. The branches generally arise almost at right angles to the parent hypha but later bend towards the direction of growth of the parent hypha and become almost parallel to it. (Plate VII, fig. 3). At this stage transverse walls are few but later they develop, dividing the hypha into cells varying in length. The septum dividing the protoplasm of the branch from the main hyphæ is usually formed at about 15 μ from the base of the branch. All branches possess that constriction at the base which is so characteristic of the genus Rhizoctonia. The main hyphæ measure at first about 6–8 μ in diameter. The branches are finer and very often measure no more than 2μ in diameter. These finer hyphæ can also be found in older cultures. At the end of the third or fourth day some of the main hyphæ increase in size and at the same time become segmented, by the formation of

septa, into short, barrel-shaped cells measuring 10–20 μ in diameter. They contain numerous oil globules and their formation is the first step towards the formation of a sclerotium. In older cultures the aerial hyphæ which have formed no part in sclerotium formation appear blackish macroscopically and microscopically.

Sclerotia.—As already stated, the first step towards the formation of a sclerotium is the division of a hypha into short, barrel-shaped cells. (Plate VIII, fig. 1). The short cells then give rise to branches which may either grow outwards and become branched, the branches anastomosing with neighbouring branches from other similar cells, or else they develop at first into short barrel-shaped cells which remain closely adhering to the sides of the parent hypha and later themselves give rise to branches (Plate VIII, fig. 2). By this process being constantly repeated and the barrel-shaped cells themselves becoming further segmented a compact mass of cells is formed, to each end of which is attached the original parent hypha. As this development goes on, the hyphæ and short cells of the sclerotium gradually turn blackish until a mature sclerotium appears as a small, black spherical body.

A sclerotium in section shows slight differentiation into cortex and medulla. The outer cortical cells are small and very thick-walled whilst the inner cells of the medulla are larger and have thinner walls. (Plate VII, fig. 1). In culture and on the host plant the mature sclerotia measure from 50 to 85 μ in diameter. Sclerotia from old cultures which have begun to dry are hard and carbonaceous and on being pressed between cover glass and slide they break up into small carbonaceous fragments which feel gritty to the touch and are not easily recognizable as fungus tissue, since the hyphæ disappear almost entirely in the formation of sclerotia.

Identification of the Fungus.

Considerable difficulty has been experienced in the identification of this fungus. It has been previously described by Shaw (32) and later by Butler (7). Shaw identified this fungus as *Rhizoctonia solani* Kühn, and for the sterile stage of the fungus *Corticium vagum* B and C he gave the name *Rhizoctonia violacea*, Tul. Butler identified the fungus as *Rhizoctonia* sp. because he takes the view that *R. solani* Kühn is the sterile form of *Corticium vagum* B and C. It was thought therefore that the fungus ought to be established as a new species of Rhizoctonia. Later, however, sweet potato tubers infested with *Sclerotium batiticola* Taub. were received by Butler at the Imperial Bureau of Mycology

from Taubenhaus. The fungus was isolated from the diseased tubers and Butler identified the Indian and Egyptian fungi and Sclerotium batticola (Taub.) as the same species. By Butler's kind permission the writer was also able to compare all three and agrees that they are one and the same species. The mode of branching, the constrictions at the base of the branch hyphæ, and the presence of septa separating the protoplasm of the main hyphæ from that of the branches are characteristic of the genus Rhizoctonia. In accordance with the laws of priority, therefore, the fungus is identified as *Rhizoctonia batiticola* (Taub.) Butl.

The Fungus on Adult Cotton.

The fungus has been described by Butler (7) as causing a root-rot of adult cotton plants in India but he qualifies his statement by saying that "it is not yet certain how far it is responsible for the observed conditions or how far it is secondary to some more serious adverse influence." He states further that the disease occurs in patches a few to many yards across, and that where the soil has been examined it has usually been found that a layer of somewhat stiff clay, mixed with "kankar" (carbonate of lime) nodules, underlies the patch at from 1 to 4 feet. Infection experiments at Pusa with the fungus on large cotton plants have failed and it is stated that if this fungus is the cause some special conditions regulate its attack.

During the investigation into the cause or causes of the wilting of cotton plants in Egypt, the writer has found that on the Experimental Farm at Gîza, and in some parts of Beni Suef the symptoms of the wilting of the cotton plant differ very markedly from those of a more widely distributed form of wilt. The latter disease is now known to be the "Wilt Disease" as known in America, and evidence is produced later in this paper to prove that the fungus causing this disease in Egypt is *Fusarium vasinfectum* Ark. The symptoms of the form of wilt occuring at Gîza and Beni Suef agree with those given by Butler (7) for the root-rot in India. Furthermore, *Rhizoctonia batiticola* (Taub.) Butl. has been isolated on several occasions from plants received from Beni Suef and at Gîza.

Infection experiments with this fungus have also been carried out at Gîza and the failure to reproduce the disease in the inoculated plants supports Butler's statement given above, namely, that infection depends on certain conditions. In spite, however, of the failure of infection experiments so far in both India and Egypt it is evident that this fungus does under certain conditions cause a root-rot of cotton.

The first symptom* apparent in the field is the yellowing and reddening of the leaves followed by a bright red colour on the leaf petioles and stem of the plant. The sides of the leaves also turn upwards and it is at these portions that the reddening is most marked on the leaves. In the case of affected leaves which are sheltered from the direct rays of the sun this reddening is either entirely replaced by the yellow colour or else they are a dull red. The leaves fall prematurely, usually breaking off at the base of the petiole but sometimes at the juncture of the leaf lamina with the petiole. Generally the lower leaves are first affected, followed in succession by the leaves on the branches above them until the plant is bare of leaves except for the young ones at the growing point. At other times odd leaves on any part of the plant are affected. The leaves at the growing point rarely fall, but turn black and the stem at the tip dies back, turning black. A dead plant has a characteristic appearance, the stem and branches being of a brilliant red except near the top, which is black.

Several cases of recovery in diseased plants have been observed at Gîza.

Unless the above symptoms are closely studied and compared with those of cotton plants suffering from the *Fusarium vasinfectum* wilt it is quite possible to consider them as the same disease. The following symptom, however, is very characteristic of the Fusarium wilt and will serve to distinguish it from the one now under consideration. The first sign of the disease is the yellowing of the smaller veins of the leaves from the edges inwards towards the mid-rib. There is no mistaking this symptom once seen in the field, because it gives, in the first stages, a rather attractive "mosaic" appearance to the leaf lamina. The small areas of the mesophyll surrounded by the small veins remain green for a time and later, if the disease progresses, the whole surface turns yellow and the leaf falls.

The tap root and stem near the surface of the ground of plants suffering from root-rot also show a characteristic symptom which makes it possible to distinguish it immediately from the Fusarium wilt. If the bark is stripped off, the bast and the surface of the wood will be found to be of a dark brown or reddish brown colour, but the inner part of the wood remains unaltered until the plant is almost

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* Since writing the above I have been informed by Mr. M. A. Bailey that he has produced symptoms apparently identical to the *preliminary* symptoms described here by growing plants in wooden tubs and subjecting them to conditions of water-shortage. Plants so treated recovered after about a week when supplied with larger amounts of water.

Furthermore Tewfik Eff. Fahmy, the present Mycologist of the Botanical Section, Gîza, has since examined several plants which had died prematurely after exhibiting all the symptoms described, without finding any decay of the cortical tissue and without any fungus being present in the tissues. A slight pinkish discoloration in their cortical tissue was however observed.

It would seem, therefore, that the symptoms described here may arise from other causes in addition to the fungus under consideration.

dead. The smaller roots will be similarly affected and in some cases the bast will be found to be entirely destroyed and the bark forming a loose cylinder round the wood. On removing the bark numerous small black sclerotia will be found on both the inside of the bark and on the surface of the wood. As in the case of Phaseolus and loubia the wood eventually breaks down into shreds owing to the destruction of the medullary rays. Sclerotia can be found in the vessels.

It is very improbable that the root-rot fungus follows the attack of *Fusarium vasinfectum* Atk. for the following reasons :—

(1) The wilting of cotton plants at Gîza Experimental Farm during the last three years has not appeared until about the middle of June. In most of the other provinces it appears in April or, at the latest, May. This is significant, since the time of sowing is about the same.

(2) The absence of the mosaic effect on the leaves which appears very early in the case of Fusarium wilt.

(3) The absence for a considerable time of any discoloration of the wood of the root and stem, near the ground level, of plants suffering from root-rot (the presence of a browning of the wood of the whole root system and of the stem for some distance above ground level is characteristic in the case of the Fusarium wilt).

(4) The absence of any discoloration of bast tissues in the Fusarium wilt and its presence in the root-rot.

In a case of double infection therefore one would find discoloration of both wood and bast, the former being affected by *Fusarium vasinfectum* Atk. and the latter by *Rhizoctonia batticola* (Taub.) Butl. Moreover, the same fungus has been found associated with the same disease in India and in two provinces in Egypt.

The Angular Leaf Spot of Cotton.

This is a bacterial disease and is caused by *Bacterium malvacearum* (Smith). The disease is well known in America (17) as well as in the West Indies and Natal. It is one of the many diseases of its kind which have not yet been investigated in Egypt. General observations, however, indicate that it is not of a serious nature, since it does not seriously affect the leaves until after the first picking. It also attacks the green bolls but not to any great extent.

The spots on the leaves measure from 1 to 5 millimetres in diameter and at first are visible only on the lower surface of the leaves Later, they are visible on both sides of the leaves as irregularly shaped reddish-black spots. The irregular outline is due to the fact that the organism does not affect the veins easily, so that the disease is generally confined to the tissue between the veins and bounded by them. The affected portion of the leaf is killed and dries up. The organism also causes spots on the bolls which are similar in colour to those on the leaves, but they are not angular. The spots on the bolls measure about 5–12 millimetres in diameter and after a time appear as blackish-red sunken areas of dead tissue. It is probable that insects which puncture the green bolls assist in infection and distribution of the disease. The disease is well known in Egypt but is wrongly known as anthracnose and said to be caused by *Glomerella gossypii* (Southw.) Edg. Anthracnose has been previously reported to occur on cotton in Egypt. After thorough searching during three seasons in Egypt the writer has found no trace of it. If present at all it must be of extremely rare occurrence.

A Wound Parasite of Cotton Bolls.

The fungus causing this disease of cotton bolls is the very common *Rhizopus nigricans* (Ehr.).

A special study was made of this disease and infection experiments were carried out which proved conclusively the pathogenicity of this organism when introduced through a wound.

The results of this study have already been published in detail in a separate technical bulletin issued by the Ministry and need not be recapitulated here. The bulletin in question is illustrated by two plates showing the appearance of infected bolls and the characteristics of the fungus itself.

(*Vide* "A Wound Parasite of Cotton Bolls." Bulletin No. 19, Technical and Scientific Service (Botanical Section), issued by the Ministry of Agriculture, Egypt.)

The Fusarium Wilt of Cotton.

Previous observations had led the writer to consider the possibility of there being more than one soil-dwelling organism in Egypt which, under favourable conditions, was capable of causing an adult cotton

plant to wilt. It was intended to make a complete study of all the forms of cotton wilt and later to make a survey of the country in respect of such diseases. Unfortunately the writer has not been able to finish this work but he strongly urges that it should be done before experiments are carried out to test the susceptibility of the different varieties of cotton against any specific wilt disease. The term "wilt disease" (Arabic *zoobool*) in Egypt covers not only the Fusarium wilt* described below but also any other form of wilt, irrespective of the cause. The custom of grouping under one name at least three distinct diseases, and possibly more, is a dangerous one and might have far-reaching results.

Wilted Plants from Kom Hamada (Beheira).

Wilted cotton plants were first reported at Kom Hamada, Beheira Province, and as early as the first week in May some fifty plants were received at the Botanical Section for investigation. These were examined thoroughly for naked-eye and microscopical characters of the disease. It was found that the bark peeled off clean and healthy. On cutting the tap roots of the majority of the plants they showed in transverse and longitudinal sections a browning of the wood which is said to be so characteristic of the disease known as "The Wilt Disease of Cotton" both in America and India. On examining microscopically the root vessels were found, in a great many cases, to be chôked up with hyaline fungus hyphæ; others did not contain fungus hyphæ but had developed globular swellings on the inside of the walls and protruded into the cavity. In a few cases these swellings, which on futher examination were found to be tyloses, almost completely filled up the cavity of the vessels.

Three plants were selected and cultures made from small portions of their tap roots in the following manner:—

The roots were first washed in running tap water and all trace of adhering soil removed by rubbing between the fingers. The roots were then washed thoroughly in several changes of distilled water and the bark stripped off by means of a sterilized scalpel. The decorticated roots were then placed in sterilized water in a beaker and cut into small pieces about half a centimetre in length. The pieces

* Work carried out in Egypt by the Mycologist since the winter's departure has shown clearly that it is a very common thing for diseased cotton plants containing a species of Fusarium and showing the brown colouration in their roots to show no sign of wilting, even though some of the other external symptomps may be present. The name "Fusarium Disease," is, therefore, now being employed by the Mycologist to designate this particular disease, the term "Wilt" being used only in a general sense and as describing a particular sympton.

of the roots were then removed from the sterilized water by means of sterilized forceps dipped in 95 per cent alcohol, flamed and placed in tubes containing sterile potato wedges. The growth obtained in these tubes consisted of a mixture of bacteria and a fungus or mixture of fungi which belonged to the genus Fusarium. Sub-cultures were made on acid media from one tube from each of the three plants, and after deciding that there was no difference in the fungus growth obtained from the three plants, one sub-culture from one plant was selected for further work.

From the sub-culture selected further sub-cultures were made by the poured plate method, and after two days small, almost colourless discs of very fine hyphæ were observed in the plate. Some well isolated discs were transferred to tubes containing acid rice. All gave reddish purple colouration after a few days. The purple colour which characterized these cultures agrees exactly with the coloured plate of the conidial stage of *Neocosmospora vasinfecta* (Smith)* in Butler's memoir (9).

Although the sub-cultures used in the infection experiments I and II described below were made in the first place from one tiny disc well isolated from others in the petri dish, it cannot as yet be definitely stated that it is a pure culture of a single strain of a single species of Fusarium, because the single disc might be the result of germination and growth of two or three microconidia belonging to different strains of Fusarium.

Experiment I.—Kom Hamada.

Five large wooden tubs were first washed out with water, sterilized by rinsing with 1 : 1,000 solution of mercuric chloride, and filled with soil which had been heated up to 100° C. About thirty seeds of Sakel (J/20) cotton were sown in each of the tubs and all watered with tap water as required. All tubs received one bucketful of water on 11–6–1922 (*see* table). One of the tubs was resown owing to the failure of the seedlings to reach the surface through stiff soil. The fungus used for infection was isolated from the wilted cotton of Kom Hamada, as described above. The colour character on acid rice was reddish purple ; on alkaline rice the colour ranged from deep purple to grey ; on acid potato the colour was pale pink.

The following table shows the progress of the disease from the date of infection :—

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* It is now generally accepted that the genetic relationship between the perithecial stage known as *Neocosmospora vasinfecta* (Smith) and the fungus causing cotton wilt in America has been disproved.

EXPERIMENT I.—KOM HAMADA.

No. of Tub.	No. of Plants after Thinning.	Date of Sowing.	Treatment.	Date of Infection.	Remarks.
1	8	19–5–1922	As described above. No fungus. (Control).	—	All plants grew up and produced flowers. On August 8, all plants uprooted and carefully examined. On cutting the roots the tissues were found white and healthy.
2	3	1–6–1922	As above. (Control)	—	
3	8	19–5–1922	As above, but 2 cultures of *Fusarium* sp. growing on acid potato wedges were broken into small pieces, stirred in bucketful of water which was then poured on surface of soil.	11–6–1922 (Age of plants, 23 days).	6–7–1922. 1 plant wilted, 2 others showing signs of wilting. 5 healthy. 9–7–1922. 3 plants wilted and dying. 3 others wilting; 2 plants healthy but smaller than other plants of same age in control. 10–7–1922. 3 wilted plants pulled up and examined. All 3 showed brown coloration of roots and vessels choked with hyphæ. 17–7–1922. All remaining plants wilting and stunted in growth. Lower leaves falling before upper ones. 24–7–1922. 2 more dead. All lower leaves fallen after turning yellow. Growing points with young leaves turning black and dying back. 3 plants still living but stunted and leaves yellowing and falling. 2 dead plants removed. 2–8–1922. 2 badly diseased and 1 slightly diseased. 4–8–1922. 1 dead and 2 very badly diseased. 8–8–1922. All plants uprooted. Roots of all brown, and fungus hyphæ in vessels.

EXPERIMENT I.—KOM HAMADA (*continued*).

No. of Tub.	No. of Plants after Thinning.	Date of Sowing.	Treatment.	Date of Infection.	REMARKS.
4	8	19-5-1922	Ditto with *Fusarium* sp.	11-6-1922 (Age of plants= 23 days).	6-7-1922. 4 plants showing signs of wilting by yellowing of leaves. 4 healthy. 9-7-1922. Some leaves of 4 diseased plants fallen after complete yellowing. 17-7-1922. 6 plants diseased, 2 healthy. 24-7-1922. 7 plants diseased. 1 healthy. Healthy plant biggest in tub. 29-7-1922. Flower opened on the healthy plant. 2-8-1922. Disease progressing. The plant which seemed healthy on 29-7-1922 showing yellowing in 2 leaves. 8-8-1922. All plants uprooted and found to show brown coloration of roots. Some more brown than others. Least of all the plant which produced flower on 29-7-1922.
5	8	19-5-1922	Ditto with *Fusarium* sp.	11-6-1922 (Age of plants =23 days).	6-7-1922. 1 plant wilted and dead. Others healthy wilted plant smallest in tub. 9-7-1922. 1 plant dead and 1 wilting, 6 healthy. 17-7-1922. 1 dead, 6 diseased, 1 healthy. 18-7-1922. Dead plant removed and examined, Root brown and vessels containing hyphæ. 20-7-1922. 1 healthy, 1 wilted. Other 5 wilting. Wilted plant removed and fungus isolated (*see* below). 2-8-1922. All plants in different stages of wilting. 8-8-1922. All plants uprooted and examined. Roots of all showed characteristic brown colouration.

NOTE.—The first symptoms of disease in the infected plants were similar to those on plants in the field. The smaller veins at the edges of the leaves turned yellow followed by those nearer the midrib. The tissue between the veins remained green for a day or so and then gradually turned yellow, dried up, shrivelled and the leaves fell to the ground.

Experiment II.—Kom Hamada.

Six holes of two plants each were selected in the field for use in this experiment. The soil was removed from around all the plants so as to expose some of the roots. Great care was taken not to damage the roots. The plants were three months old. After removing the soil two litres of tap water was poured on the roots of plants in three of the holes and the soil replaced. These three holes served as controls. After exposure of roots in the other three holes two litres of tap water with a culture of *Fusarium* sp. (as in Experiment I) in suspension was poured in roots as in case of controls.

The plants in all holes were observed from time to time and up till the end of August no sign of disease was observed in either the infected or controls.

The failure of infection in this experiment following the decided success of Experiment I, was very instructive since the only essential difference was in the age of plants at time of infection.* It opened up a line of investigation to find out how early and to what age the fungus was able successfully to attack and cause a cotton plant to wilt. (*See* Experiment IV.)

Isolation of Parasite from Tub V, Experiment I.—The fungus was re-isolated from a diseased plant in Tub V, Experiment I, as follows :—

(i) Side roots cut off and the tap root thoroughly washed under a running tap. All soil removed by rubbing between fingers.

(ii) Washed in several changes of distilled water.

(iii) Washed in sterilized water and bark removed with flamed scalpel.

(iv) Washed again in fresh sterilized water and cut into small pieces about half centimetre in length. Sections made of one or two of the pieces and fungus hyphæ found in vessels.

(v) Pieces taken in sterilized forceps, dipped in alcohol, flamed, and placed on sterile potato wedge medium.

Growth was contaminated with bacterial organisms. The fungus was then sub-cultured on to acid potato medium.

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* Since writing the above I have been informed by Tewfiq Eff. Fahmy, working at Giza, that he has successfully infected cotton plants (Sakel) of up to 126 days in age. In these cases, no external symptoms were visible, but the central cylinder of the root was discoloured and contained hyphæ of Fusarium.

(vi) One of the sub-cultures on acid potato was selected and a small piece of mycelium with conidia taken on the point of a sterilized needle and introduced into a test tube containing sterilized water and shaken. A platinum loopful of the sterilized water with conidia in suspension was placed in a second test tube with sterilized water and finally diluted for the third time.

(vii) A loopful of the water from the third dilution was then placed in the centre of a sterilized petri dish, the cover replaced, and the drop of water examined under the microscope by inverting the petri dish. It was found impossible to count the microconidia with any degree of certainty under the low power, and the high power could not be used owing to the thickness of the petri dish. After several trials, however, a loopful was introduced into each of three petri dishes and as far as could be judged under the low power, each drop of water contained a small fragment of mycelium and no conidia. A loopful from dilution tube No. 1 was placed in a fourth petri dish. This contained several microconidia. Prune agar was then poured into the four petri dishes.

The growth obtained in the four petri dishes was as follows :—

Petri Dish No. I.—Three discs of growth, one culture was made from the edge of each. After a few days there were found to be two pure cultures of *Penicillium* and one pure culture of *Aspergillus niger*.

Petri Dish No. II.—Eight discs of growth, four of which were *Aspergillus niger* bearing sporangia. Cultures were made from the other four discs and after a few days were found to be two of *Aspergillus niger*, one *Cladosporium*, and one *Penicillium*.

Petri Dish No. III.—Five discs of growth, two of them *Aspergillus niger* with sporangia; other three subcultured. Of the three subcultures made, one was *Rhizopus nigricans* and the other two were *Fusarium* sp. which gave reddish purple colouration on acid rice.

Petri Dish No. IV.—Several discs of growth and bacterial colonies. Discs of *Aspergillus niger* with sporangia. As in petri dishes I–III the discs of *Aspergillus* and *Penicillium* were recognisable from those of the *Fusarium*, being much denser. Sub-cultures were made, however, so as to account for all the discs after production of sporangia or conidia. Five sub-cultures were made from five isolated discs of what was thought to be the *Fusarium*, and grown on acid rice. All turned reddish-purple after a few days.

One of the two sub-cultures of *Fusarium* from petri dish No. III was taken, and several sub-cultures made from it and used for infection experiment III (Kom Hamada) and for culture characters on the different media.

Experiment III.—Kom Hamada.

Nine tubs sown with 30 seeds each of Sakel J/20, water added till soil was saturated. Seed sown on August 2, 1922.

Appeared above soil on August 8, 1922. (Soil taken from canal bank. Tilth very good. Texture light loam.)

No. of Tub.	Treatment.	Date of Infection.	Remarks.
1	Seedlings thinned down to 8 plants on August 10. (Best 8 chosen). 1 litre of tap water added—poured on soil round plants.	—	
	No fungus. (Control).	—	
2	ditto. (Control).	—	
3	ditto. (Control).	—	
4	As above, but a culture of *Fusarium* sp. was broken into small pieces and suspended in the water. Water and culture in suspension then poured on soil as above. Fungus used obtained from infected plant in Tub V, Experiment I. (Infected).	10–8–1922	27–8–1922. 1 plt. dis. 7 healthy. 29–8–1922. 2 plts. ,, 6 ,, 2–9–1922. 3 ,, ,, 5 ,, 5–9–1922. 5 ,, ,, 3 ,, 9–9–1922. 6 ,, ,, 2 ,, 14–9–1922. 7 ,, ,, 1 ,, 16–9–1922. 8 ,, ,, ——
5	ditto.	10-8–1922	27–8–1922. 1 plt. dis. 7 healthy. 30–8–1922. 2 plts. ,, 6 ,, 31–8–1922. 4 ,, ,, 4 ,, 2–9–1922. 5 ,, ,, 3 ,, 9–9–1922. 6 ,, ,, 2 ,, 16–9–1922. 7 ,, ,, 1 ,, 24–9–1922. 8 ,, ,, ——
6	ditto.	10–8–1922	22–8–1922. 1 plt. dis. 7 healthy. 27–8–1922. 2 plts. ,, 6 ,, 28–8–1922. 3 ,, ,, 5 ,, 31–8–1922. 5 ,, ,, 3 ,, 5–9–1922. 7 ,, ,, 1 ,, 12–9–1922. 8 ,, ,, ——

EXPERIMENT III.—KOM HAMADA (*continued*).

No. of Tub.	Treatment.	Date of Infection.	REMARKS.
7	As above, but a culture of *Fusarium* sp. was broken into small pieces and suspended in the water. Water and culture in suspension then poured on soil as above. Fungus used obtained from infected plant in Tub V, Experiment I. (Infected).	10–8, 1922	27–8–1922. 2 plts. dis. 6 healthy. 28–8–1922. 4 ,, ,, 4 ,, 29–8–1922. 5 ,, ,, 3 ,, 31–9–1922. 6 ,, ,, 2 ,, 5–9–1922. 7 ,, ,, 1 ,, 24–9–1922. 8 ,, ,,
8	ditto.	10–8–1922	30–8–1922. 1 plt. dis. 7 healthy. 31–8–1922. 3 plts. ,, 5 ,, 2–9–1922. 5 ,, ,, 3 ,, 5–9–1922. 6 ,, ,, 2 ,, 9–9–1922. 7 ,, ,, 1 ,, 16–9–1922. 8 ,, ,,
9	ditto.	10–8–1922	25–8–1922. 2 plts. dis. 6 healthy. 27–8–1922. 5 ,, ,, 3 ,, One of the 5 attacked plants removed for culture work. 9–9–1922. 7 plants dis. (including the one taken for culture work). 1 healthy. 10–9–1922. 8 plants dis.

NOTE.—The term "diseased" in the above table signifies that the plants showed *external* symptoms of disease.

Experiment IV.—Kom Hamada.

Ten tubs sown with 30 seeds each of Sakel J/20. Water added till soil was saturated. Seed sown on August 15, 1922. Appeared above surface August 21, 1922. Soil as in Experiment III.

No. of Barrel.	Treatment.	Date of Infection.	Remarks.
1	Plants thinned to best 8 plants on August 22, 1922 Watered with tap water as required.	—	
	No. fungus (Control).	—	
2	ditto. (Control).	—	
3	ditto. (Control).	—	
4	Thinned to 8 plants on August 22, 1922. Culture of *Fusarium* sp. broken up by hand placed with seed in soil. Fungus isolated from infected plant in Tub V, Experiment I. (Infected).	August 15	27– 8–1922. 4 plants attached in the cotyeldons. 4 healthy. 29– 8–1922. 5 plants diseased. 3 ,, healthy. 16–10–1922. 6 ,, diseased. 2 ,, healthy.
5	Culture of *Fusarium* sp. broken up and suspended in 1 litre of tap water and poured round roots of 8 plants. (Infected).	August 22	9– 9–1922. 1 plt. dis. 7 healthy. 10– 9–1922. 2 plts. ,, 6 ,, 14– 9–1922. 4 ,, ,, 4 ,, 16– 9–1922. 5 ,, ,, 3 ,, 12–10–1922. 6 ,, ,, 2 ,, 15 10–1922. 7 ,, ,, 1 ,, 4–11–1922. 8 ,, ,, 1 diseased plant died on 12–10–1922 and 2 diseased plants on 4–11–1922.
6	As above, but fungus not added until August 29. (Infected).	August 29	12– 9–1922. 2 plts. dis. 6 healthy. 14– 9–1922. 4 ,, ,, 4 ,, 16– 9–1922. 5 ,, ,, 3 ,, 24– 9–1922. 7 ,, ,, 1 ,, 12–10–1922. 8 ,, ,, 2 dis. plts. died on 15–10–1922. 2 ,, ,, 1–11–1922. 2 ,, ,, 7–11–1922.

EXPERIMENT IV.—KOM HAMADA (*continued*).

No. of Barrel.	Treatment.	Date of Infection.	REMARKS.
7	As above, infection on September 5. (Infected).	Sept. 5	24– 9–1922. 1 plt. dis. 7 healthy. 10–10–1922. 3 plts. ,, 5 ,, 15–10–1922. 5 ,, ,, 3 ,, 19–10–1922. 6 ,, ,, 2 ,, 1 plant died on 7–11–1922.
8	As above, infection on September 12. (Infected).	Sept. 12	24– 9–1922. 2 dis. plts. 6 healthy. 2–10–1922. 3 ,, ,, 5 ,, 10–10 1922. 4 ,, ,, 4 ,, 15–10–1922. 5 ,, ,, 3 ,, 6–11–1922. 6 ,, ,, 2 ,,
9	As above, infection on September 19. (Infected).	Sept. 19	8–10–1922. 2 dis. plts. 6 healthy. 12–10–1922. 3 ,, ,, 5 ,, 15–10–1922. 4 ,, ,, 4 ,, 4–11–1922. 6 ,, ,, 2 ,, 6–11–1922. 7 ,, ,, 1 ,, 1 diseased plant died on 1–11–1922. 3 diseased plants died on 7–11–1922.
10	As above, infection on September 26. (Infected).	Sept. 26	8–10–1922. 1 dis. plt. 7 healthy. 12–10–1922. 2 ,, plts. 6 ,, 6–11–1922. 4 ,, ,, 4 ,, 12–11–1922. 5 ,, ,, 3 ,,

NOTE.—The term "diseased" in the above table signifies that the plants showed *external* symptoms of disease.

Experiment V (in Pots).—Kom Hamada.

Three pots containing soil sterilized in an autoclave, and 20 seeds of Sakel J/20 sown in each. The seeds were first soaked in a solution of copper sulphate, 2 per cent, for 10 minutes.

Distilled water added till soil was saturated. Seed sown on August 29, 1922. Seedlings appeared above soil on September 3, 1922. Soil as in Experiment IV.

No. of Pot.	Treatment.	Date of Infection.	Remarks.
1	No fungus. (Control.)	—	
2	Infected with *Fusarium* sp. Isolated from Tub 9. Experiment III, Kom Hamada.	14–9–1922	30– 9–1922. 1 dis. plt. 5 healthy. 14–10–1922. 3 „ plts. 3 „ 22–10–1922. 1 „ plt. died. 1–11–1922. 4 „ plts. 2 healthy. 7–11–1922. 1 more of diseased plants died.
3	Infected with the same fungus as No. 2.	14–9–1922	24– 9–1922. 1 dis. plt. 5 healthy. 12–10–1922. 3 „ plts. 3 „ 24–10–1922. 4 „ „ 2 „ 4–11–1922. 5 „ „ 1 „ N.B.—One of the diseased plants died on 18–19–1922, two on 1–11–1922 and one more on 7–11–1922.

Note.—The term "diseased" in the above experiment signifies that the plants showed *external* symptoms of disease.

Wilted Cotton Plants from Damanhur (Beheira) 1923.

Two parcels of plants were received from two localities in Markaz Damanhour. Both lots of plants showed the brown colour in the wood of the roots, and hyphæ were found in vessels. In two sections microconidia were found in the wood vessels. One plant from each lot was taken and cultures made from fragments which had been treated in a similar manner to those from Kom Hamada. Poured plates were also made and small pieces of mycelium from discs well isolated from others transferred to acid rice. All these produced the same reddish purple coloration observed in the case of the fungus from Kom Hamada. No infection experiments were carried out with the fungus isolated from these plants.

Wilted Cotton Plants from Sharqîya (1922).

Wilted cotton plants were sent in to the laboratory by the Inspector of Agriculture, Sharqîya, in the middle of June. In view of the fact that large areas of cotton are affected in this Province, and there being a possibility that the causal organism is different from that causing the disease in Beheira it was considered desirable to isolate the parasite and to carry out infection experiments. The symptoms, namely, the browning of the wood and presence of hyphæ in the vessels, were exactly similar to those of the disease from Beheira. This, however, does not indicate with certainty the cause of the disease.

Isolation.—The fungus in the vessels of the tap roots was isolated in the same manner as described above. The poured plate method was used, and isolated discs transferred from the petri dishes to tubes containing sterile acid rice. All these gave reddish purple coloration. One tube was chosen and the fungus again plated for the second time. As before, all cultures on acid rice gave the reddish purple coloration. Sub-cultures were made from one of these cultures and used in the following infection experiments :—

Experiment I.—Sharqîya 1922.

No. of Tub.	Treatment.	Date of Sowing.	Date of Infection.	No. of Plants.	Remarks.
1	Tube sterilized with 1 : 1,000 Perchloride of Mercury. Soil heated to 100° C. Water heated to 60° C. Soil removed on 11–7–1922 so as to expose roots, ½ litre of water poured into hole. Soil replaced. No fungus. (Control).	11 6 1922	—	8	Healthy up till Aug. 11, 1922.
2	ditto. (Control).	11–6–1922	—	—	ditto.
3	As above, but 2 cultures of *Fusarium* sp. broken into small pieces and added to ½ litre of water on 11–7–1922. (Infected).	11–6–1922	11–7–1922	8	29–7–1922. 6 plants dead, 2 diseased. 30–7–1922. Dead plants examined. Roots brown and hyphæ in vessels. 2–8–1922. All plants dead.
4	ditto. (Infected).	11–6–1922	11–7–1922	8	29 7–1922. Healthy. 2–8–1922. Cotyledons of 3 plants showing first signs of wilting and yellowing of veins. 5 healthy. 4–8–1922. Disease progressing. 8–8–1922. 4 dead, 4 diseased. 9–8–1922. 5 dead, 2 diseased, 1 slightly. 13 8 1922. 5 dead, 1 badly diseased and collapsed, 1 badly diseased and standing. 1 showing symptoms in cotyledons only.

Experiment II.—Sharqîya 1922.

For use in this experiment two small ridges measuring about $1\frac{1}{2}$ metre long, and about 10 metres from each other were closed at both ends so that watering could be done by means of buckets. In one of the ridges 4 holes were made about 10 centimetres deep and about 40 centimetres apart. Into each of these holes half litre of water with fungus in suspension was poured. The holes were then filled with soil and about 30 seeds sown directly above so that the roots would grow into the infected soil. The same procedure was carried out in the case of the second ridge but no fungus was suspended in the half litre of water poured into the holes. This second ridge served as control. After sowing on July 11, 1922, both ridges were thoroughly watered on the same day.

Result.

INFECTED.				CONTROL.			
Hole I.	Hole II.	Hole III.	Hole IV.	Hole I.	Hole II.	Hole III.	Hole IV.
Number of Plants after thinning 5.	Number of Plants 4.	Number of Plants 0. (Destroyed by Cutworm).	Number of Plants 7.	Number of Plants 8.	Number of Plants 8.	Number of Plants 8.	Number of Plants 8.
8–8–1922 1 dead 4 healthy	8–8–1922 2 diseased 2 healthy		8–8–1922 4 diseased 3 healthy	All healthy.	All healthy.	All healthy.	All healthy.
12–8–922 No change	12–8–1922 1 dying. Examined and roots brown. 1 diseased 2 healthy		12–8–1922 1 dead. Examined and roots brown. 3 diseased 3 healthy				

The above experiment was abandoned because by this time sufficient evidence had been ascertained to show that the disease on the Gîza Experiment Farm was root-rot and *not* Fusarium wilt. It was therefore highly desirable not to introduce a new parasite. The infected soil was treated with carbon bisulphide and after a week dug up thoroughly and the soil exposed to the sun.

Identification of the Fungus.

The parasitic *Fusarium* sp. isolated from wilted cotton received from different localities in Egypt forms, like many members of the same genus, three types of spores, namely, the microconidia, macroconidia, and chlamydospores. Spores intermediate in form between the micro and macroconidia are also formed in culture (Plate IX, figs. 3 to 5). Nothing is to be gained by giving here a lengthy description of the size and form of these conidia, because it has been definitely shown by Butler (9) that agreement in this respect is not sufficient to identify a species of Fusarium. The cultural characters of the *Fusarium* sp. causing a wilt disease of cotton in Egypt are as follows :—

On Steamed Potato Wedges.—Growth at first white, and macroconidia, microconidia, intermediate forms and chlamydospores formed. Macroconidia are formed in larger numbers on this medium than on any other on which the fungus has been grown. After a time the fungus forms whitish sclerotoid bodies on the substratum and the latter becomes somewhat greyish in colour.

On Acid Potato Wedges.—These were prepared by soaking the wedges for 20 minutes in 1 per cent sulphuric acid and then rinsing in water, placing in tubes, and sterilising in an autoclave in the usual manner (9).

Growth at first white, but later became pinkish in colour. Macroconidia few, and microconidia very numerous.

On Acid Carrot Wedges.—Prepared as above. Colour at first white, then pink, somewhat deeper than on acid potato wedges. Microconidia very numerous.

On Alkaline Rice.—Prepared by placing rice in a beaker containing tap water and adding solution of sodium carbonate until litmus paper turned blue ; the rice was then boiled, tubed, and sterilized in an autoclave.

Growth at first white, then turned dirty grey with suggestion of purple.

On Acid Rice.—As above, but dilute solution of hydrochloric acid added until litmus paper turned red.

Growth of the fungus on acid rice was very characteristic, and it is on the colour character on this medium that the identification of the fungus is based. At first growth is copious and the substratum pinkish but rapidly changing to a light reddish-purple. At the end

of a month the substratum was of a rich reddish-purple colour. No further changes in colour were observed for several months. Macroconidia present, but microconidia far more numerous.

No perithecia have been observed either in the field or in any of the culture media used.

The above cultural characters of the fungus agree with the descriptions of the conidial stage of *Neocosmospora vasinfecta* (Smith) as described by Erwin Smith and are quite distinct from those described by Butler (9) for his *Fusarium udum*. The latter fungus gives a deep brick-red colour in contact with the substratum when grown on acid rice and a similar but paler colour on alkaline rice. No suggestion of this colour has been seen in any of the many cultures of the Egyptian Fusarium made. According to Butler (9) the cause of Egyptian cotton wilt has been identified as *Neocosmospora vasinfecta* (Smith) by Delacroix (Sur la Maladie du Cotonnier en Egypte. Extrait de l'Agriculture Pratique des Pays Chauds, Vol. II, 1902–1903). The writer has been unable to obtain Delacroix's paper for reference, and has, moreover not observed a perithecial stage, and is therefore unable to refer the fungus to any other genus but Fusarium.

The fungus is therefore considered to be *Fusarium vasinfectum* (Atk.).

Physiological Wilt Disease of Cotton.

Some plants were received at the Laboratory from another locality in Beheira Province which were said to be suffering from the wilt disease. Microscopical examination of the root systems indicated that they were perfectly healthy. The stems of the plants, however, had become shrunken for a length of about two inches above the ground level. This gave the appearance of a swollen node on the stem at about two inches above the ground. The bark of the shrunken portions of the stems was dark brown and longitudinal sections showed that the internal tissues were also dark brown. The discoloration of the internal tissues of the stems extended the whole length of the lower shrunken portions and for a considerable distance above. The affected crop was examined, and on making enquiries it was found that the cotton was being grown as a reclamation crop on very salty land. In order to wash away the salt the cultivator had flooded the land and kept the water on the land for about two days. Thus the shrunken portions of the plant stem had been submerged in water for two days and possibly more. Possibly the root system had been asphyxiated by submersion in water for a long period. This is the only case of its kind that the writer has observed in Egypt and it is mentioned because it shows clearly the danger of overwatering the cotton plants and presents an interesting physiological problem.

PULSE.

Broad Bean (*Vicia Faba*).

Rust (*Uromyces Fabæ* Pers. de B.).

Only the uredo and teleuto stages of this rust are found in Egypt. The disease occurs throughout the country. In Upper Egypt it does not cause very much damage but throughout Middle Egypt and the Delta it is a very serious disease.

Downy Mildew (*Peronospora Viciae* Berk. de B.).

The disease forms greyish patches on the under surface of the leaves and although common it does not cause much damage.

French Bean (*Phaseolus vulgaris* L.).

Rust (*Uromyces appendiculatus* Pers. Lk.).

Like the broad bean rust, only the uredo and teleuto stages occur on the plant in Egypt. The distribution is general and although severe attacks have been observed, yet it is not as serious a disease as the rust of broad beans. The same fungus attacks Loubia (*Vigna sinensis*).

Loubia (*Vigna sinensis*).

Rust (*Uromyces appendiculatus* Pers. Lk.).

Satisfactory means of controlling this disease are now possible in Egypt since a very resistant variety is known. Under the most trying conditions of moisture only a few pustules were discovered on the resistant variety whereas another variety growing side by side under similar conditions was very badly rusted.

Garden Peas (*Pisum sativum* L.).

Downy Mildew (*Peronospora Viciae* Berk. de B.). (*See* Broad bean).

Powdery Mildew (*Erysiphe Polygoni* D.C.).

In other countries this fungus attacks many plants belonging to different families but, up to the present, it has only been found on garden peas in Egypt. It is an unimportant disease in this country although its distribution is general.

CEREALS.

Barley (*Hordeum vulgare* L.).

Closed or Covered Smut (*Ustilago hordei* Pers. Kell. and Sw.).

This is the most serious smut of cereals in Egypt. With the exception of the bunt of wheat an account of the rusts and smuts of wheat, barley and oats has already been published. (*See* Bull. No. 15, Technical and Scientific Services, Min. of Agr., Egypt, 1920.)

Loose Smut (*Ustilago nuda* Jens. Kell. and Sw.).

This is of rare occurrence in Egypt.

Black Rust (*Puccinia graminis* Pers.).

The damage caused by this disease is not serious on barley in Egypt. It also occurs on wheat, oats, and *Hordeum murinum* L.

Yellow Rust (*Puccinia glumarum Eriks. and Henn.*).

Like the black rust, this also attacks wheat and to a far greater extent than barley.

Stripe Disease (*Helminthosporium gramineum* Rabenh.).

The stripe disease is not so serious in Egypt as it is in England (10) where damage to the extent of 5 to 10 per cent in some counties was estimated in 1919. Nevertheless, a fair amount of damage is caused by this disease. The mode of infection resembles very closely that of the closed smut. The conidia of the fungus adhere to the seed coats and after sowing the seed these conidia germinate and infect the young seedling. The method of controlling the disease is exactly similar to the treatment against closed smut, *viz.* : formalin.

Late Blight (*Helminthosporium teres* Sacc.).

The fungus causing this disease is indistinguishable from that causing the stripe disease but its effect on the plant makes it easily distinguishable in the field. Instead of causing long brown stripes on the leaves, this disease forms dark brown spots on both sides of the leaves. The disease is not common and has only been observed in patches. For the present no special treatment is necessary. Treatment of the seed with formalin is also effective against this disease.

Oats (*Avena sativa* L.).

Smut (*Ustilago Avenæ* Pers. Jens.).

Oats are not grown extensively in the country except on Government farms. The amount of smut on the latter is considerable and in view of the fact that the disease is easily controlled by treating the seed with formalin, it is too abundant. Steps should be taken against the disease especially if seed from infected crops is to be distributed amongst cultivators in different parts of the country.

Black Rust (*Puccinia graminis* Pers.). Has been observed to occur.

Maize (*Zea Mays* L.).

Rust (*Puccinia Maydis* Bereng).

Although the rust occurs in the majority of maize crops throughout the country it has not yet been observed to cause any damage worth considering.

Leaf Blight (*Helminthosporium turcicum* Pass).

This disease produces brownish-yellow spots on the leaves which often coalesce, forming long stripes. The blight is not widespread and when found it generally occurs only on the lower leaves. The fructifications of the fungus are visible with the naked eye as a dark green mould on the diseased portions of the leaves.

Millet (*Andropogon Sorghum* Brot.).

Grain Smut (*Sphaceolotheca Sorghi* (Lk.) Clinton).

Head Smut (*Ustilago Reiliana* Kühn).

Long Smut (*Tolyposporium filiferman* Busse).

The above three smuts are the only fungous diseases which have been observed on millet. An account of these diseases has already been published (*see* Bull. No. 18, Bot. Section, Min. of Agr., Egypt, 1921).

Wheat (*Triticum spp.*)

Black Rust (*Puccinia graminis* Pers.)

Yellow Rust (*Puccinia glumarum* Eriks. and Henn.).

Orange Rust (*Puccinia triticina* Eriks.).

An account of these rusts has already been published (*see* Bulletin No. 15, Technical and Scientific Service, Ministry of Agriculture, Egypt, 1921).

Black rust on wheat is one of the most serious plant diseases in the country, and detailed observations carried out on over fifty different varieties have shown that generally speaking, the Indian wheats are more susceptible than the native (*Beladi*) wheats.

Yellow rust is most serious on the native (*Beladi*) wheats, although some of the Indian and Australian wheats are also badly attacked.

Loose Smut (*Ustilago tritici* Pers. (Jens.).

The loose smut occurs in almost every crop of wheat grown in the country but it is never in sufficient quantities to justify any special treatment being taken against it.

Mould (*Mycosphaerella Tulasnei* Janez—*Cladosporium herbarum* (Lk.).

Although the cladosporium stage of this fungus is met with everywhere in Egypt on decaying vegetable matter yet the disease caused by it on wheat is of rare occurrence. Apparently the fungus requires very damp conditions before it is able to attack the living wheat plant. A very serious combined rust and mould attack was observed at Mansûra in 1921. The cause of this severe attack of both diseases was excessive watering and heavy rainfall. The rust and mould between them completely destroyed the crop.

Bacterial Disease (*Pseudomonas tritici* Hutch.).

This disease of wheat was first recorded in the Punjab and a detailed study of the organism was made by Hutchinson (25). He described the disease as follows: "The inflorescence and parts of the stem are covered with a bright primrose yellow slime or gum, forming adherent sticky layers between the glumes and between the

stem and sheath. This slime is composed of masses of bacteria and the outer exposed portions become dried up, hard, and flaky, and at the same time take on a deeper yellow tone. A frequent characteristic, due to the interference of the sticky bacterial masses with the growth and expansion of the plants, is the distortion of the stem immediately below the head . . ." (Plate XI).

This disease was first recorded in Egypt about ten years ago but up till recently it does not seem to have caused much damage. In the spring of 1922 several diseased crops were examined in different localities in the Delta and another at Beni Suef. The loss caused at Beni Suef was estimated at 40 per cent of the crop and other crops in Menufia were found to be damaged to the extent of 25 per cent. The diseased crop of Indian wheat at Beni Suef was thrashed on ground which was subsequently sown with Beladi wheat, and it was found that the disease had spread from the Indian to the native (Beladi) wheat crop. All the other diseased crops examined were Indian varieties. It seems very probable that the disease has been introduced into Egypt from India. As in India, the disease is often found in Egypt to be closely associated with eelworm attack.

Control.—The disease is slowly but surely spreading throughout the country and extensive inquiry has led to the conclusion that the spread is effected by putting on the market seed from diseased crops for sowing purposes. Unless definite remedial measures are taken against this disease in Egypt it is safe to predict that in another ten to fifteen years it will rank as one of the most serious diseases of plants in the country. The following measures are recommended against the disease:—

(1) In cases where the damage is estimated at anything up to 30 per cent of the affected crop the wheat should be threshed on the spot, the straw burned, and the grain sold for consumption only. On no account should grain from a diseased crop be used for sowing purposes.

(2) Where the damage is estimated at over 30 per cent the whole crop should be burned on the ground.

(3) The soil is generally left fallow after wheat until the following August, when maize is sown. It is probable, therefore, that the heat of the sun during June and July would raise the temperature of the surface soil above the thermal death point (50° C.) of the causal organism, thereby rendering any soil treatment unnecessary.

Effectively to check the spread of this disease will cost the country a considerable sum of money but the sooner a campaign is organised to combat it, the less will be the amount spent.

Bunt (*Tilletia Levis* Kühn).

The bunt of wheat is a disease which attacks wheat in every country where the crop is grown. The life history of the fungus is similar to that of the closed smut of barley and the smut of oats. The bunt spores adhere to the seed and are sown with it in the soil. In the moist soil both seed and spore germinate and infection takes place by the penetration of the epidermal cells of the young wheat seedling by the fungus germ tube. The time of infection is limited to a period of eight or ten days after the commencement of seed germination. After the entrance of the fungus into the host tissues a mycelium is produced which grows upwards in the tissues of the wheat, keeping pace with the growing stem. At the time when the ears are formed the fungus replaces the young ovaries by a mass of hyphæ which eventually produce a mass of dark brown spores which are enclosed by the glumes. When the crop is fully ripened it is not possible to distinguish the diseased from the healthy without thorough examination. On crushing a diseased head between the hands the spore balls will be broken showing the dark brown masses of spores which have a very disagreeable smell resembling that of rotten fish.

Treatment is by immersion of the seed before sowing in a 2 per cent solution of copper sulphate for 1 minute, then drying in the sun. Any unbroken spore balls present will float on the surface and should be removed. A far easier and equally effective treatment is to immerse the seed in a 0·25 per cent solution of formalin (*i.e.* the commercial formalin, which contains about 40 per cent of Formaldehyde) for 10 minutes. Then place the seed in a heap on the floor or in a convenient vessel, cover with a damp cloth for two hours, dry, and sow.

The disease seems to be confined to Upper Egypt and does not occur north of Minya. It occurs mostly at Asyût. The most common type of wheat grown in the localities where bunt occurs is the native variety known as "Dakkar," and the disease seems to be almost entirely confined to this wheat. Dakkar wheat has no special property which makes its cultivation very desirable, so that in Egypt treatment of seed by chemicals need not be resorted to. The very obvious thing to do is to cease growing this very susceptible wheat and to substitute for it a better type of wheat which is not attacked. Cases of damage up to 25 per cent have been observed in Dakkar wheat crops.

ROOT CROPS.

Beet (*Beta vulgaris* L.).

Leaf Spot (*Cercospora beticola* Sacc.)

The fungus attack is characterised by the formation of greyish-brown spots on the leaves. The margins of the spots are reddish at first but later become blackish. When the attack is severe the leaves lose their green colour, turn yellow and fall off. The disease is rare on crops grown in the open, but if beets are grown in a shady, damp place they become badly diseased. Only the older leaves are attacked because the stomata of the younger leaves do not open sufficiently to allow the fungus germ tubes to enter. The disease is very prevalent on plants which are allowed to run to seed.

Turnip (*Brassica campestris* L.).

Leaf Blight (*Alternaria Brassica* Berk. Sacc.—*Polydesmus exitiosus* Kühn).

Like the leaf spot of beet this disease becomes serious only on turnips which are grown in shaded and damp places. The spots on the leaves resemble the beet leaf spots except that they are lighter in colour. They are about the same size, generally measuring about a half-centimetre in diameter.

VEGETABLES.

Globe Artichoke (*Cynaria scolemus* L.)

Powdery Mildew (*Oidiopsis taurica* Lev. Salm. *Erysiphe taurica* Lev.).

It is the lower leaves of the plant that are seriously damaged, and the mildew, which occurs on the under surface of the leaves, causes them to wilt and dry up. The upper leaves are not badly affected and retain their green colour. At the end of the season numerous perithecia are found on the lower leaves. The usual spraying and sulphur dusting methods of control cannot be used on this plant owing to the difficulty of application to the undersides of the leaves. Before any remedial measures can be suggested a study of the cultural methods will have to be made.

Root-rot (*Sclerotium Rolfsii* Sacc.).

In October 1920 three per cent of the globe artichoke (*Cynaria scolemus*) plants in the Horticultural Section Gardens, Gîza, were found to be suffering from what appeared to be a root-rot disease. The plants had wilted and dried up and could easily be pulled out of the ground because the rootlets had been destroyed. The underground portion of the plant was found to be covered with a dense white mass of fungus mycelium which resembled combed-out cotton fibre in appearance (Plate X). Intermingled with the mycelium and attached to it were numerous small mustard seed-like bodies which on examination were found to be the sclerotia of the fungus.

The rotted plants were brought into the laboratory and cultures made from single sclerotia, which were previously washed in several changes of distilled water, and from the white weft of mycelium. There was no difficulty experienced in isolating this fungus since no other fungi were found growing in the cultures made and the separation from bacterial organisms was easily accomplished owing to the fact that the fungus grew very rapidly up the sides of the tubes and outpaced the bacteria.

The cultures made from sclerotia and mycelium consisted at first of a luxurious growth of white, tough hyphæ similar to those found on the artichoke roots. After four or five days young sclerotia could be distinguished as small, white, rounded bodies measuring 1 to 2 millimetres in diameter. The sclerotia later turned a buff

colour and when mature they became dark brown and smooth (Plate X). The sclerotia appear to be formed on a pedicel about 1 millimetre in length which is composed of closely adhering hyphæ. At maturity, the sclerotia lose connection with these hyphæ and can be shaken about in the tube like mustard seeds. Often two or three sclerotia may become fused together into groups. The hyphæ on being placed in water adhere closely to each other longitudinally and require to be carefully teased out with a needle before the course of a single hypha can be followed under the microscope. The hyphæ give rise to several branches from the same point and these again may become joined to each other and to the parent hypha by means of numerous clamp connections. The main hyphæ vary in size, measuring 5 to 7μ in diameter (Plate IX, figs. 1–2). Some of the finer branches measure only 2μ in diameter. A section of sclerotium shows that the exterior is brown and the centre white. It is differentiated into three distinct kinds of tissue, *viz.*: the epidermis, the cortex and the medulla. The epidermis consists of one or two layers of brown, thick-walled, rectangular cells. The cortex consists of six to eight layers of hexagonal parenchyma-like cells, and the medulla consists of short hyphæ with numerous intercellular spaces.

If the fungus is kept growing on agar medium for a long period it will be observed that, after each transfer to fresh agar medium, the sclerotia produced gradually decrease in size. If these small sclerotia or a piece of the mycelium be then transferred to potato wedges the sclerotia produced will regain their original size of about 2 millimetres in diameter at the first transfer. The fungus has been grown on potato for two years, being transferred to fresh medium about once every ten days and the sclerotia have retained their normal size throughout.

Experiment I. Eight flower pots each containing a healthy young globe artichoke plant growing in untreated garden soil. Portions of the root systems were exposed and in six pots a small portion of a culture of *S. Rolfsii* was placed near the roots and then earthed up again. The other two earthed up without placing any fungus at the roots. These served as control plants. All pots were watered, immediately after treatment, on the 23-10-1920. Subsequent watering were given to all pots every few days. Tap water was used.

Results.

No. of Pot	Date.	Remarks.
1 (Control)	25–11–1920	A slight wilting of the outer leaves. Plant growing.
	29–11–1920	No change.
2 (Control)	25–11–1920	Plant healthy, growing.
3	6–11–1920	Outer leaves wilting and stalk soft at ground level with the fungus growing on it.
	25–11–1920	Some of inner leaves wilting and outer leaves dead. Healthy new shoot given out.
	29–11–1920	Original shoot collapsed. Two more healthy young shoots growing.
4	6–11–1920	Outer leaves wilted.
	25–11–1920	All leaves in different stages of wilting.
	29–11–1920	New shoot growing.
5	6–11–1920	Healthy.
	25–11–1920	Whole plant wilting.
	29–11–1920	No marked change.
6	1–11–1920	The plant (smaller than the others) was dead and roots covered with a thick weft of mycelium of *S. Rolfsii*. Underground portion with mycelium and sclerotia.
7	6–11–1920	Plant thought to be dead.
	16–11–1920	Two new shoots given out.
	25–11–1920	A third shoot growing. One of the other two shoots wilting.
	29–11–1920	The new shoot that was wilting 25–11–1920 is dead. Another new shoot had appeared.
8	6–11–1920	Original shoot dead. New shoot growing, healthy.
	25–11–1920	The plant had produced two new shoots and on this date they were dead.
	29–11–1920	No change.

Observations were not made after the 4–12–1920 because the plants became very badly attacked by aphides. On this date the roots of the infected plants were examined and found covered with a thick growth of *S. Rolfsii*. The fungus was isolated from the root of the plant in pot No. 8. No further experiments were possible with this host plant because the plants could not be obtained. In the course of the above experiment it was observed that the fungus requires **much moisture for rapid growth.**

Experiment II.—In this experiment the same kind of dishes were used as in the previous infection experiments (*vide* Cotton Sore-Shin) and the treatment was the same, *viz.*: the dishes were sterilized with copper sulphate solution and then filled with sterilized sand and watered with distilled water; five seeds of the host plants were sown in each dish and the fungus placed with the seeds.

Name of Plant.	No. of Dish.	Treatment.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings.	Remarks.
Castor Oil.	1	No fungus. (Control).	24–10–1920	4–11–1920	5	Healthy.
	2	ditto. (Control).	,,	,,	4	Healthy.
	3	With *S. Rolfsii.*	,,	,,	—	Seedlings killed before appearing above surface. Mycelium and sclerotia on surface of sand.
	4	ditto.	,,	—	—	Ditto.
	5	ditto.	,,	—	—	Ditto.
Peas.	1	(Control).	24–10–1920	30–10–1920	5	Healthy.
	2	,,	,,	,,	5	Healthy.
	3	With *S. Rolfsii.*	,,	—	—	Sclerotia and mycelium on surface of sand. None reached the surface.
	4	ditto.	,,	—	—	Ditto.
	5	ditto.	,,	—	—	Ditto.
Phaseolus.	1	(Control).	24–10–1920	30–10–1920	5	Healthy.
	2	,,	,,	,,	5	Healthy.
	3	With *S. Rolfsii.*	,,	—	—	None reached surface.
	4	ditto.	,,	—	—	Ditto.
	5	ditto.	,,	30–10–1920	1	Dead on 3-11-1920. *S. Rolfsii* in tissues.

EXPERIMENT II (*continued*).

Name of Plant.	No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings.	REMARKS.
WATER MELON	1	(Control).	24-10-1920	3 11 1920	3	Healthy.
	2	,,	,,	,,	5	Healthy.
	3	With *S. Rolfsii.*	,,	—	—	None reached surface. *S. Rolfsii* isolated from tissues.
	4	ditto.	,,	—	—	None reached surface.
	5	ditto.	,,	—	—	Ditto.
PUMPKIN	1	(Control).	24-10 1920	1-11-1920	4	Healthy.
	2	,,	,,	2-11-1920	5	Healthy.
	3	With *S. Rolfsii.*	,,	—	—	None reached surface.
	4	ditto.	,,	—	—	Ditto.
	5	ditto.	,,	—	—	Ditto.
BAMIA	1	(Control).	24-10-1920	1-11-1920	5	Healthy.
	2	,,	,,	,,	5	Healthy.
	3	With *S. Rolfsii.*	,,	—	—	None reached surface.
	4	ditto.	,,	—	—	None reached surface. Fungus in tissues.
	5	ditto.	,,	—	—	None reached surface. Sclerotia and mycelium on surface of sand.
CABBAGE	1	(Control).	24-10-1920	30-10-1920	3	Healthy.
	2	,,	,,	,,	2	Healthy.
	3	With *S. Rolfsii.*	,,	—	—	
	4	ditto.	,,	30-10-1920	1	Diseased, but lived till 4-11-1920. *S. Rolfsii* in tissues.
	5	ditto.	,,	,,	—	

EXPERIMENT II (*continued*).

Name of Plant.	No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings.	REMARKS.
COTTON	1	(Control).	24–20–1920	31–10–1920	5	Healthy.
	2	,,	,,	,,	5	Healthy.
	3	With *S. Rolfsii.*	,,	—	—	None reached surface. *S. Rolfsii* isolated 4–11–1920
	4	ditto.	,,	,,	—	None reached the surface.
	5	ditto.	,,	—	—	ditto.

Experiment III.—The treatment in this experiment was the same as in Experiment II, five seeds sown throughout. The fungus was isolated from cotton in Experiment II.

Name of Plant.	No. of Dish.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings.	REMARKS.
CASTOR OIL	1	(Control).	11–11–1920	29–11–1920	5	Healthy. Germination slow, due to cold.
	2	(Control).	,,	,,	5	ditto.
	3	Infected.	,,	—	—	None appeared.
	4	,,	,,	—	—	ditto.
	5	,,	,,	—	—	ditto.
PHASEOLUS	1	(Control).	11–11–1920	23–11–1920	5	Healthy.
	2	(Control).	,,	,,	5	ditto.
	3	Infected.	,,	—	—	None appeared.
	4	,,	,,	—	—	ditto.
	5	,,	,,	—	—	Ditto. and *S. Rolfsii* isolated from diseased tissues.

Experiment III (*continued*).

Name of Plant.	No. of Dish.	Treatment.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings.	Remarks.
Garden Peas	1	(Control).	11–11–1920	19–11–1920	5	
	2	(Control).	,,	,,	5	
	3	Infected.	,,	—	—	
	4	,,	,,	—	—	
	5	,,	,,	—	—	
Water Melon	1	(Control).	11–11–1920	28–11–1920	3	
	2	(Control).	,,	,,	3	
	3	Infected.	,,	—		
	4	,,	,,			
	5	,,	,,	—	—	
Pumpkin	1	(Control).	11–11–1920	23–11–1902	5	
	2	(Control).	,,	,,	3	
	3	Infected.	,,	—	—	
	4	,,	,,	—	—	
	5	,,	,,	—	—	
Bamia	1	(Control).	11–11–1920	23–11–1920	5	
	2	(Control).	,,	,,	3	Diseased on 25 11 1920. Dead. Examined, cause *Corticium vagum*. Imperfect sterilization of sand.
	3	Infected.	,,	—	—	
	4	,,	,,	—	—	
	5	,,	,,	—	—	
Ground Nut	1	(Control).	11–11–1920	29–11–1920	5	
	2	(Control).	,,	,,	5	
	3	Infected.	,,	—	—	
	4	,,	,,	—	—	
	5	,,	,,	—	—	

Experiment III (*continued*).

Name of Plant.	No. of Dish.	Treatment.	Date of Sowing	Date of Appearance of Seedlings.	No. of Seedlings.	Remarks.
Cotton	1	(Control).	11-11-1920	22-11-1920	4	
	2	(Control).	,,	,,	5	
	3	Infected.	,,	—	—	
	4	,,	,,	—	—	
	5	,,	,,	—		

Experiment IV.—Treatment as in Experiments II and III. Five seeds sown throughout.

The fungus used was isolated from Phaseolus in Experiment III.

Name of Plant.	No. of Pot.	Treatment.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings.	Remarks.
Phaseolus	1	(Control).	11-12-1920	21-12-1920	5	
	2	(Control).	,,	,,	5	
	3	Infected.	,,	,,	—	
	4	,,	,,	—	—	
	5	,,	,,	—	—	
Peas	1	(Control).	11-12-1920	21-12-1920	5	
	2	(Control).	,,	,,	5	
	3	Infected.	,,	—	—	
	4	,,	,,	—	—	
	5	,,	,,	—	—	
Water Melon	1	(Control).	11-12-1920	26-12-1920	2	
	2	(Control).	,,	,,	2	
	3	Infected.	,,	,,	—	
	4	,,	,,	,,	—	
	5	,,	,,	,,	—	
Pumpkin	1	(Control).	11-12-1920	21-12-1920	4	
	2	(Control).	,,	,,	4	
	3	Infected.	,,	,,	—	
	4	,,	,,	,,	—	
	5	,,	,,	,,	—	

EXPERIMENT IV (*continued*).

Name of Plant.	No. of Pot.	TREATMENT.	Date of Sowing.	Date of Appearance of Seedlings.	No. of Seedlings.	REMARKS.
BAMIA	1	(Control).	11–12–1920	21–12–1920	5	
	2	(Control).	,,	,,	5	
	3	Infected.	,,	,,	—	
	4	,,	,,	,,	—	
	5	,,	,,	,,	—	
GROUND NUTS	1	(Control).	11–12–1920	21–12–1920	—	This failure was probably due to cold.
	2	(Control).	,,	,,	—	
	3	Infected.	,,	,,	—	
	4	,,	,,	,,	—	
	5	,,	,,	,,	—	
COTTON	1	(Control).	11–12–1920	25–12–1920	5	
	2	(Control).	,,	,,	4	
	3	Infected.	,,	—	—	
	4	,,	,,	—	—	
	5	,,	,,	—	—	

The above infection experiments show that the fungus is able to attack and kill with equal readiness the seedlings of all the plants tried. Although only one experiment was carried out with artichoke there is no doubt that the fungus is able to attack it under favourable conditions of moisture. With regard to the parasitism of this fungus Stevens (38) states: "This sterile fungus possesses a very aggressive mycelium which, under favourable conditions of moisture, grows on almost anything, living or dead . . ."

Identification of the Fungus.—On comparing the morphological characters of this fungus with the description and plates of the fungus described by Shaw and Ajrekar (33) as *Rhizoctonia destruens* (Tass), it became evident that these were one and the same species. At the outset, however, the writer disagreed with the above authors' identification because, except for the fact that it is sterile, there is no point of similarity between this fungus and members of the genus Rhizoctonia. On further comparison with Stevens' (38) description

and figure the fungus was identified as *Sclerotium Rofsii* Sacc. Shaw in a letter to the writer also stated that he has considered for some time the possibility that the fungus which he knows under the name of *R. destruens* might be identical with *Sclerotium Rolfsii*, Sacc.

Control.—The method of controlling the damage caused by this fungus has not yet been worked out, but thorough cultivation and summer fallow might do a great deal towards killing the fungus in the soil.

Cabbage (*Brassica oleracea* L.).

Downy Mildew (*Peronospora parasitica* (Pers.) Tul.).

This disease is known in other countries to attack many plants of the family Cruciferæ. In Egypt it is known to occur on cabbage, cauliflower, and the cruciferous weed Sisymbrium. The attacks observed have not been severe enough to justify special treatment being taken against this disease. Should it become necessary, an application of a fungicide such as Bordeaux mixture coupled with the removal of all cruciferous weeds would be effective.

Celery (*Apium graveolens* L.).

Leaf Spot or Early Blight (*Cercospora Apii* Fr.).

As the name implies, the fungus forms spots on the leaves. They are yellow in colour and sometimes coalesce. The borders of the spots are slightly raised and the diameter ranges from $\frac{1}{4}$ to $\frac{3}{4}$ inch. When treatment is necessary spraying with Bordeaux mixture checks the disease.

Egg Plant (*Solanum Melongena* L.).

Powdery Mildew (*Oidiopsis taurica* (Lev.) Salm.—*Erysiphe taurica* Lev.).

As previously mentioned, the same mildew also attacks globe artichoke. Only slight attacks have been observed on the egg plant. No perithecia have been found on this host.

Lettuce (*Lactuca sativa* L.).

Downy Mildew (*Bremia Lactucæ* Reg.).

This is a very common disease of lettuce in Egypt, and it often causes considerable damage to the outer leaves. It also occurs on Sonchus. The conidiophores of the fungus appear as a whitish growth on the under surfaces of the leaves. The affected areas turn yellow and attacked leaves are said to have a bitter taste. In bad attacks the whole under surface of the leaves is covered with the fungus and the leaves wilt and shrivel up. Lettuce is grown on both sides of ridges in Egypt and an experiment was carried out with a view to controlling the disease by spraying with Bordeaux mixture and by sulphuring by means of a machine. Although both fungicides killed the fungus where they came in contact with it, neither method is to be recommended because it does not repay the labour and cost of application. The only suggestion that can be given at present is to avoid excessive nitrogenous manuring and to afford the maximum of light and free passage of air within the crop by wider spacing of the plants. Nitrogenous manuring stimulates growth and the plants produce large dark green leaves which keep out the light and thus favour the fungus. Furthermore, these large plants are not in favour with the fellaheen because the leaves are coarse and not so sweet to the taste. It is interesting to note that the European cabbage lettuce is not attacked in Egypt but only the Egyptian variety.

Potato (*Solanum tuberosum* L.).

The Ring Disease (*Bacillus solanacearum* Smith).

The only locality in which this disease has been recorded was at Gemmeiza in 1922. The ring disease of potatoes is also well known in Europe, India, and the United States. It is characterized in the field by the sudden wilting and drying up of the leaves and stem. The causal organism invades the tissues of the stem, roots and tubers. The name of the disease is derived from its effect upon the tubers. When cut through an almost complete ring of brown tissue will be found in the flesh of the tuber about a quarter of an inch under the skin Diseased tubers do not keep well and soon become shrivelled up. They also have a disagreable flavour after cooking. Infection is from organisms which are present in the soil and from diseased tubers used as seed. Diseased plants raised from diseased tubers serve as a source of infection to neighbouring healthy plants. The same organism causes a similar disease in tomatoes, egg plant, and tobacco, so that

these plants should not be grown on infected land. Thorough cultivation followed by summer fallow and the use of healthy seed are the best means of combating the disease.

The diseased crop at Gemmeiza was very badly attacked. The potatoes were not fit for human consumption.

Purslain (*Portulaca oleracea* L.).

White Rust (*Cystopus portulaceæ* D.C. Lev.).

White rust appears as white or pale yellowish blisters on the leaves and stems. Purslain grows both as a weed and as a cultivated plant in Egypt and is used as a vegetable.

Spinach (*Spinacea oleracea* Mill.).

Downy Mildew (*Peronospora effusa* (Grev.) Rabh.)

This disease of spinach is known in many other countries to cause severe damage in mild, muggy weather, but in Egypt the attacks are generally very slight.

Tomato (*Lycopersicum esculentum* Mill.).

Fruit Rot (*Macrosporium tomato* Cke. and *Alternaria solani* (E. and M.) Jones and Grout).

The fruit-rot disease can easily be distinguished in the field as a large sunken area with a copious growth of the dark green almost black conidiophores. Two fungi are present, *viz.*:— Alternaria and Macrosporium. They are quite distinct from each other and at present it is unknown whether one or both are able to attack the tomato fruit.

Bamia (*Hibiscus esculentus* L.).

Powdery Mildew (*Erysiphe Cichoracearum* D.C.).

This mildew attacks several members of the family Cucurbitaceae and others in different parts of the world, and in Egypt in addition to bamia it has the following hosts :—

Tyl (*Hibiscus cannabinus*).
Melon (*Cucumis pubescens*).
Cucumber (*Cucumis sativum*).

Vegetable Marrow (*Cucurbita Pepo*).
Marrow (*Cucurbita leginaria*).
Sweet Melon (*Cucumis dudain aegyptiacum*).

The fungus is visible mostly on the upper surfaces of the leaves, covering them with a white powdery coating. When severe it causes the leaves to turn yellow and wilt. The fungus also attacks the fruit and stems of the plants. Sulphur dusting is in use against this disease in Egypt and spraying with Bordeaux mixture also has the desired effect. Bordeaux is preferable to the sulphur treatment since treatment of large areas can be done quicker and the cost of the chemicals and labour is considerably less. Fruit sprayed with Bordeaux mixture is not poisonous.

FRUITS.

Almond (*Prunus communis* L.).

Rust (*Puccinia pruni-spinosæ* Pers.).

This is a general parasite on the leaves of stone-fruit trees all over the world. In Egypt it also attacks the leaves of plum and apricot. The disease never becomes serious until the fruit is picked, but later it gets bad enough to cause defoliation. It is possible that this is an exceptional case of a fungus disease doing good to the tree rather than harm, since the weather in Egypt is rarely cold enough to cause complete defoliation in the winter. This statement is equally applicable to the disease on the plum, apricot, and peach.

Citrus.

Wither Tip (*Colletotrichum gloeosporioides* Penz.).

With the exception of the mandarin orange this disease attacks the leaves, fruit, and twigs of citrus trees in Egypt. It causes the tips of young branches to wither and the leaves on the affected portions to fall off. After death the tips of the branches take on an ashen-grey appearance. On the leaves and fruit the fungus causes spots which measure anything up to $\frac{2}{3}$ inch in diameter. The spots are sunken and often the fungus can be seen as small black specks in the centre of the diseased tissue. The damage caused by this disease in Egypt is very much overestimated. The reason for this being that if there is a clear line of demarcation between diseased and healthy tissue it is immediately put down to "Wither tip." This has led to much confusion between this and a far more serious disease known as "Die-back" or "Exanthema." All that need be done to check "Wither tip" in Egypt is to cut and burn all affected portions, whether the branch, leaf, or fruit.

Die-Back or Exanthema.

This disease has not been associated with any specific organism and the conditions which favour it are: (1) Excessive dressings of nitrogenous manure in its organic form; (2) lack of drainage; (3) uneven

and excessive watering; (4) hard pan. As in the case of wither tip, this disease causes the younger branches to die back, but to a far greater extent. In no case has wither tip been observed in Egypt to cause the dying-back of branches to more than 45 centimetres from the tip, whereas exanthema often affects big arms about a yard long. The line separating the diseased from healthy tissues is often clearly marked in die-back, but the following two symptoms serve to distinguish it from wither tip. (1) The dead twigs do not take on an ashen-grey appearance but turn a light reddish-brown colour; (2) it is almost invariably accompanied by an exudation of gum on the dead branches, particularly at the points of attachment of the side branches; (3) the affected branches are twisted. The effect on the fruit is very characteristic and cannot be mistaken for any other disease. The fruit at maturation is inclined to shrivel up owing to loss of turgidity in the rind cells, and often the fruit cracks longitudinally from the base towards the stem end. Small heads of gum are often exuded at the point where the splitting commences. Dark irregular markings sometimes occur on the fruit rind.

The remedial measures against this disease are :—

(1) The removal of all dead arms by pruning.

(2) The substitution of organic nitrogenous manure by the mineral form.

(3) The method of watering recommended below under Gummosis.

Sun-Scorch.

This is a disease which is known to affect the leaves of various fruit trees in many parts of the world. If affects orange leaves mostly in Egypt, particularly the large light green leaves which are produced on water shoots. The causes of the disease are said to be numerous, particularly those factors which prevent the root system from performing the full amount of absorption. General observation in different parts of the country indicates that it is caused mostly by the intense heat of the sun on the undersides of the leaves which are exposed to the sun's rays. The effect of the sun's rays would probably cause a greater effect if bright sunshine early in the day followed a heavy fall of dew during the night. The affected portions of the under surface of the leaves are slightly raised owing to the formation of cork cambium in the mesophyll of the leaves. This raised portion is brown in colour.

Black Rot (*Alternaria citri* Pierce).

The fungus gains entrance into the tissues of the fruit through wounds made by insects or other agents. It causes sunken spots or patches on the fruit which is generally hard and dry and covered with the dark green, almost black, fungus. It is of rare occurrence and the damage caused is negligible. It is important, however, not to pack affected fruit with the healthy otherwise the disease will spread.

Penicillium Rot (*Penicillium italicum* Wehmer and *Penicillium digitatum* Fr.).

Like the black rot fungus these moulds do not infect uninjured fruit. They cause a soft rot of damaged fruit, particularly those which hang near or touching the ground. It also attacks fruit which has fallen off the tree. When fruit is packed in quantity, all fruit showing the first sign of rotting should be removed, because the spores are produced in large numbers (they can be seen as a blue-green or a pale green covering on the surface of the fruit) and serve as a means of spreading the disease. In orchards, the source of infection can be greatly reduced by strict and prompt sanitary measures such as the burning or burying of all diseased fruit whether on the trees or on the ground.

Sooty Mould (*Capnodium citricolum* McAlpine).

The fungus mycelium forms a black covering of the fruit, leaves and the younger parts of the branches. It is not a parasite but grows saprophytically on the honey-dew which is excreted by insects of the families Coccidae and Aphidae. The mycelium and honey-dew together form a sticky mass which can be easily removed by wiping with a damp rag. Treatment should aim at the destruction of the insect or insects which excrete the honey-dew.

Gummosis.

Fawcett (20) has described seven diseases which cause gumming of the trunk and larger branches of citrus trees in Florida and California. Several attempts have been made in Egypt to isolate a causal organism from the diseased crown roots and trunks of citrus trees but without success. Comparison of the symptoms of the diseased trees in Egypt with the description and plates given by Fawcett has led to the conclusion that the main trouble is due to a fungus called *Pythiacystis citrophthora* (Fawcett). Cases of gummosis occur

in Egypt which agree with Fawcett's (20) description and figures of both the brown rot and the Mal di Gomma or foot rot. The author states, however, that probably the Mal di gomma is only a form of brown rot or *Pythiacystis gummosis* which occurs lower down at the base of the trunk and the crown roots.

The disease is characterized by the exudation of gum from the forks of the main branches and also from the trunk at, or just above, the crown. Sometimes the bark cracks longitudinally but otherwise appears uninjured. For a time large amounts of gum are exuded through these cracks but later the flow ceases and on examination it will be found that the tree has formed callus on the inside of the wood which has been killed. At other times no longitudinal splitting of the bark on the trunk takes place but the bark at the crown and on the main crown roots can be easily peeled off. This is due to the destruction of the phloem tissues. The wood underlying this bark is soft, dry, and dead and has a fœtid smell. The rot works round the base of the tree and in many cases does not extend to more than a foot above the crown. This is due to the fact that conditions of moisture near the ground level favour the growth of the fungus.

The disease occurs in both Upper and Lower Egypt, but is more severe where drainage is bad and on heavy lands. This is the most serious disease of fruit trees in Egypt and the damage caused by it in some parts of the country has caused much anxiety to several growers. Fortunately, however, a very satisfactory means of control is known. The extent of the disease depends to a very large extent on the variety of citrus grown. Mandarins are very resistant if not entirely immune to the disease. Several varieties of lemons and oranges are grown, but only two kinds of stock are used. These are known as the "Naringh" and the "Torong" (Citron). The most popular stock is the "Torong" because it is more readily obtainable, and a crop of fruit is obtained about two years earlier than when the "Naringh" stock is used. It is no exaggeration to state that it is a practical impossiblity to grow healthy trees in Egypt if the very susceptible "Torong" stock is used. On the other hand orchards can be kept in a healthy condition if the highly resistant "Naringh" stock is used and provided the method of watering and cultural operations described below are carried out.

There are at present many large orchards in Egypt which are badly damaged by this disease, and the following recommendations are made in regard to treatment :—

(1) To replace in one season a large number of diseased trees by young and healthy trees which have been grafted on resistant stock would mean a tremendous loss to the growers. That this must be done sooner or later is certain, but the loss would not be felt if this

were done gradually. The proportion which can be replaced each year, must, of course, depend on the availability of young trees and the amount of capital which the growers can afford to invest.

(2) Fawcett Surgical Method.—This method of treatment was demonstrated and tried in this country on a large scale at the beginning of 1922. The results of these trials, however, are not yet known. It is stated (20) that many trees suffering from the disease have been cured in Florida. It consists of removing the soil so as to expose the diseased roots and cutting out with a knife all the decayed portions of the crown and roots, giving them a thorough dressing with a strong fungicide.

The fungicide used was Bordeaux paste as recommended by Fawcett (20); one pound of copper sulphate dissolved in three quarts of water in an earthenware vessel (metal vessels must on no account be used); two pounds of fresh quick lime slaked in three quarts of water in another vessel. Care should be taken to add the water little by little so that the lime breaks up into fine powder. When all the water has been added mix the copper sulphate solution with the milk of lime and stir thoroughly. If the lime is fresh and properly slaked the result will give a light blue coloured paste. This paste should be applied to the wound made after cutting away all diseased wood. It is advisable to make only sufficient paste as will be required on the day it is made. If kept for three or four days it loses in great part its fungicidal properties. The mixture should not be allowed to get on the hands because it removes the skin, causes the flesh to crack and is very painful.

(3) Citrus trees are planted in rows about 15 feet apart, the same distance being kept between the trees. Watering is done either by running the water through water channels between the rows of trees or else channels are made so that the trees stand in the middle of the water channels. In the case of canals between rows, the soil removed in their making is banked up on each side, thereby covering the main crown roots and part of the trunks. In the second case the water is allowed actually to come in direct contact with the trunks of the trees.

Both these methods are distinctly favourable to the disease, because the soil around the trunks and main crown roots is kept almost continually moist. There is no object in this, since neither the base of the trunk nor the large crown roots function as absorbing organs.

The method of watering recommended is as follows. Keep the water channels between the rows, but instead of putting the soil round the trunks of the trees, it should be placed between the trees. The soil around the trees should be removed so as to expose the whole of the

trunk and at least a foot of the main crown roots. The removed soil should be banked up about a yard away from the trunk and all round it. Thus the tree will stand in a saucer-shaped hollow and no water should be allowed to run into it. If the trees are large and it is considered that the one canal between rows is not sufficient, then matters can be easily rectified by making at right angles to the main water channels other smaller ones between the trees which will join the main channels. Incidentally the soil in which the absorbing roots are growing will thus be more evenly watered.

(4) It has often been observed that, in the event of a few trees being removed in an orchard, these are replaced by small young trees. The same amount of water is given to these as the remainder, which are much larger trees. It is clear, therefore, that either the larger trees are getting insufficient water or else the smaller are getting too much. Care should be taken to plant trees which are uniform in size throughout the orchard or at least throughout any one row. When a plantation is first planted with young trees the use of one canal between the rows of trees is not satisfactory and should be substituted by two smaller canals made nearer the trees. As the trees grow these can be made further and further from the trees until they eventually come together and form the one central canal as before. As soon as the young trees become firmly fixed in the soil steps should be taken to expose the trunk and main roots as explained above.

(5) It is customary to allow citrus trees to go for two months (*i.e.* during December and January) without water. At the end of this period the trees are manured and a heavy watering is then given. No detailed experiments have been carried out to investigate the effect of this heavy watering after a period of rest for two months but it seems possible that it may do more harm than good.

Melanose (*Phomopsis citri* Fawcett).

This disease is well known in Florida (20), but neither this form of the disease nor the stem-end rot caused by the same fungus has been found in California. In Egypt it has been observed on the twigs, fruit and leaves of oranges and mandarin. The stem-end rot, as described by Fawcett (21), has not been observed but only the Melanose disease.

According to Stevens, H.E. (37), the damage is caused as follows; the source of the disease is in the dead tissue and branches, where the fungus grows and produces fruit bodies (pycnidia) containing abundance of conidia. When dead bark containing pycnidia is moistened by heavy dew or rain the conidia are released through the necks

of the pycnidia and washed down on to the leaves, fruits and twigs below. If the conidia fall on dead wood they germinate and produce pycnidia with conidia. On the other hand if they fall on to the fruit, leaves, or succulent parts of the twigs they germinate and later perish. They do not grow into the living tissues, but the living cells on which germination has taken place are killed. This is probably due to a toxin produced by the germinating conidia. The injury caused is the same in appearance on the young green twigs, leaves and fruits. Small carbonaceous spots are produced on the surface. They are dark brown in colour and raised owing to the formation of cork cambium by the living cells underlying those killed by the germinated conidia. The production of a layer of cork and the growth of the cambium cells pushes out and raises the group of dead cells above the general surface.

The disease is not serious in Egypt, and the tear-staining effect of fruit described in Florida has not been observed. The damage is confined to the formation of small spots measuring about 2–4 millimeters in diameter. The pycnidia were found on dead twigs caused by "wither tip" and "exanthema." At the present time no treatment is necessary and the removal of dead wood by pruning as recommended against both "wither tip" and "exanthema" or "die-back" would remove the source of infection.

Date (*Phoenix dactylifera* L.).

Leaf Smut (*Graphiola phœnicis* Poit.).

The date palm leaf smut is a very well known disease in Egypt. The sporocarps of the fungus appear on the leaves as black, hard, carbonaceous bodies which are raised above the surface of the leaves. The centres of the spots are sometimes pale yellow or golden in colour, due to the colour of the spores which have been liberated by the opened sporocarp. In section the sporocarp is shown to consist of a hard, black, compact outer peridium which encloses another group of elongated cells known as the inner peridium. Both the outer and inner peridium form a protective covering to other more delicate hyphæ which they enclose. These hyphæ are of two kinds, namely, fertile hyphæ and sterile hyphæ. The fertile hyphæ are short, segmented, and bear at their apices a chain of spores. The sterile hyphæ are also segmented but are three or four times as long as the fertile hyphæ. They are intermingled with the fertile hyphæ and serve to distribute the spores. The spores adhere to the sides of the sterile hyphæ which project through the mouth of the sporocarp after it has opened. With the aid of a lens the sterile hyphæ with adhering spores can be seen projecting from the centre of the opened sporocarp. They are pale yellow in colour.

The spores fall or are blown by the wind on to the healthy parts of the leaves where in the presence of moisture they germinate and produce fresh sporocarps. The disease is severe only on neglected palms. Those whose outer leaves are regularly pruned do not suffer badly. After pruning, the leaves which have been removed should be burned. This would considerably reduce the source of infection.

Fig (*Ficus carica* L.).

Rust (*Uredo Fici* Cast.).

The rust on fig leaves has only been examined on specimens sent in for identification so that an estimate of the damage caused cannot be given. It is probably not serious, otherwise the writer would have received more than a few enquiries about it.

Grape (*Vitis vinifera* L.).

Downy Mildew (*Plasmopara viticola* (B and C) Berl. and De Toni).

The downy mildew of the grape occurs in every country where the fruit is grown. The conidiophores bearing conidia are produced in patches on the under surfaces of the leaves, and appear whitish in colour. The portions of the upper surfaces of the leaves corresponding to the areas of the lower surfaces on which the fungus is visible gradually turn yellow and later brown. Grapes grown on badly drained land or in shaded places would suffer more severely than those grown in open places and on well drained land. It is interesting to note that the now well known fungicidal compound Bordeaux Mixture was first used against this disease in 1881 by Millardet in France. A thorough application of Bordeaux mixture $1\frac{1}{2}$ per cent strength is a very efficient method of control, and is in use in several countries.

Leaf Spot (*Cercospora viticola* Ces. Sacc.).

This is of rare occurrence and has only been observed on dwarf vines. The leaves hanging near the ground were the most badly attacked. The spots are visible on both sides of the leaves and are dark brown or reddish-black in colour. The conidiophores bearing conidia are borne on the under surfaces of the leaves and with the aid of a lens can be seen in the centre of the spots as a greyish growth. In cases of necessity treatment with Bordeaux mixture, as in the case of the downy mildew, would stop the spread of the disease.

Mango (*Mangifera indica* L.).

Mildew (*Oidium Mangiferæ* Berthet).

Only one case of this disease has so far been recorded. The attack in this case, however, was serious and occurred at Qorashîya in 1922. The mildew attacks the inflorescences just at the time when the fruit is set. It causest he shedding of large numbers of young fruits and flowers. The presence of white downy growth on the inflorescences makes this disease easily recognisable from the other disease mentioned below. The disease was first recorded on Mango in South America and the fungus described and named by Berthet (5). Spraying with Bordeaux mixture and lime sulphur would probably kill the fungus, but before applying the former fungicide it should be first tried on a small scale to see how the spray affects the inflorescences. It might prove injurious and cause shedding of flowers and young fruits.

Mango Blight (*Bacillus mangiferæ* Doidge).

This very serious disease of mango trees of all ages and varieties grown in Egypt remained unidentified for some time. It was at first thought that it might be due to a fungus, but repeated attempts to isolate a possible fungus parasite failed. Later, however, the probable cause was suggested to the writer by a plate in Dr. Erwin F. Smith's (35) book which was added to the library. The plate referred to is a reproduction of Miss Doidge's Plate VI (13). By communicating with Dr. E. J. Butler, Director, Imperial Bureau of Mycology, Kew, England, a copy of Miss Doidge's paper was obtained with others for reference. Careful observation of the symptoms and microscopical examinations suggest strongly that the disease is the same as the one which has been fully described by Miss Doidge.

The disease is said to cause considerable damage in all the mango-growing districts of the Union of South Africa with the exception of Zoutpansberg. So far as can be ascertained the disease, at the present time, is not known except in South Africa and Egypt.

The effects of the disease on different organs are:—

On the leaves.—At first small, irregularly shaped, water-soaked spots appear and for a time these are bounded by the veins of the leaf. Later, however, thse spots increase in size and often coalesce so as to involve large areas of the leaves. They also change colour, becoming dark brown, and sometimes there is a small amount of gum exuded from the lamina. More often, however, gum is exuded from the leaf stalk.

Miss Doidge states that the principal agent in spreading the disease is the wind. In South Africa insects are not considered to be responsible for the spread of the disease to any great extent. Wind probably spreads infection in Egypt also but observations have led the writer to conclude that the chief agents are a species of Thrips and a mite of the genus Tetranychus. The mite is chiefly responsible because small colonies of mites collect on the under sides of the leaves and near the base. At this point the disease is almost invariably present and there is no doubt that these as well as the Thrips convey bacteria on their legs and bodies which gain entrance easily through the punctures made by these animals in the tissues of the plant. The badly diseased leaves eventually become white, shiny, dry, brittle and are often cracked.

On the stem.—The green parts of the branches are also attacked and the bacillus produces dark brown or almost black patches which measure usually half an inch to an inch in diameter. On cutting through these diseased areas it will be found that the tissues are affected and discoloured to a considerable depth. Sometimes the greater part of a branch will be affected, and as the disease progresses large longitudinal cracks appear in the bark.

On fruit.—It is often the case that the whole inflorescence is affected at flowering time. The tissues become discoloured and the flowers fall off in great numbers. If the young fruit is attacked these are affected in a similar manner, causing hundreds of young mangoes to fall to the ground. The chief seat of infection for fruits of all ages seems to be the point of attachment to the stalk. A very characteristic symptom of the disease is the exudation of gum at the stem end of the fruit. This spreads over the surface of the fruit and is charged with the infecting bacilli so that it is highly infectious. Fruit at all ages thus affected fall to the ground at the slightest touch. The rot works inwards and downwards through the flesh and finally completely rots the seed. Infection also takes place at the points where the fruits touch each other. At this point dew collects and this of course facilitates infection by the bacilli. On an old infected area large cracks occur and the surface becomes roughened and irregular.

Miss Doidge (13) in her account of the disease describes experiments carried out with a view to controlling the disease. She summarises these results as follows : " Spraying experiments have been conducted which show that spraying with Bordeaux mixture, iron sulphide or hycol is useless in checking the disease." It is also stated that sanitary measures such as gathering and burning all diseased fruit and leaves slightly reduces infection. However, no really effective measures are known up to the present. Examination

of numerous slightly diseased fruits has shown that often the disease progresses as far as the testa of the seed. This indicates that the disease may be carried in the seed testa or even the inner tissues of the seed, provided they are not so badly affected as to destroy the germinating powers. Further work is necessary, however, before any definite statements can be made.

Peach (*Prunus Persica* Benth. and Hook.).

Peach Leaf Curl (*Exoascus deformans* (Berk.) Fuckell).

This common disease of peach is known in every country in the world where the fruit is grown. Its distribution is general in Egypt but like a good many other fungus diseases it is serious only in sheltered, neglected or damp orchards. When the attack is severe in any orchard it is invariably accompanied by a far more serious disease known as Gummosis (*see below*). The commencement of the attack occurs just at the time when the young leaves unfold in the early spring. The fungus is visible with the naked eye and covers the surface of the leaves with a white mealy growth. It is sometimes confined to one portion of the leaf and at other times wholly covers the leaf surface. The affected portion becomes puckered or curled up in a very characteristic manner and as the disease progresses the leaves lose their green colour, turn pale yellowish and finally fall to the ground. In addition to the curling of the leaf surface the disease causes the tissues to swell up. Transverse sections show that they are much thickened and the area of the leaf surface may be as much as four or five times that of the normal leaves. Treatment is by spraying with Bordeaux mixture 1 per cent strength. This, however, should be applied a few days before the leaf buds open in the early spring.

Gummosis.

As the name implies, this is characterised by the exudation of gum from the tissues of the plant. The gum exudes from all the limbs, from the crown to the youngest twig in severe cases. Large beads of clear gum flow down the branches and main stem. After a time the gum hardens and becomes brown in colour. This is a severe disease in Egypt and causes great loss to peach growers. So far the cause or causes of this disease are unknown, but observations made in different localities throughout the country clearly show that this, in common with so many other plant diseases, is far more serious on badly drained lands and on plants which have been planted near the watering channels. Attempts to grow peaches on heavy, badly drained land

should not be made because failure is inevitable. Where it is desirable to plant a few peach trees in a garden they should be planted in a part where special attention can be given to them. Trees grown at odd intervals in or near vegetable beds which require watering frequently suffer very much from this disease, and yield no fruit. This disease in Egypt is a pathological problem which requires very careful investigation. A similar disease affects the plum and apricot.

Plum (*Prunus* spp.).

Powdery Mildew (*Podosphaera Oxyacanthæ* De C. De Bary).

The powdery mildew occurs on the leaves of young plants but only very rarely, and to a slight degree.

Strawberry (*Fragaria* spp.).

Leaf Spot (*Mycosphærella fragariæ* (Schweinitz) Lindau).

At first the spots caused by this fungus are dark red or purplish in colour and are visible on the upper surface of the leaves. As the spots increase in size they measure up to a quarter of inch in diameter. The centre turns whitish and is bounded by a ring of purplish tissue. If the spots are numerous they often coalesce, and cause the leaf to turn yellow, shrivel up, and die.

An intersting case of a susceptible variety serving as a source of infection for more resistant varieties was observed at the Garden of the Horticultural Section, Gîza, in 1921. The susceptible plants were of the English variety known as "St. George." The whole crop covered an area of about a quarter of feddan (acre) and consisted mainly of the Beladi (native) variety. On the south-western corner were growing about half a dozen plants of the "St. George" variety. Alongside of these were a few rows of the "Laxton" variety and the remainder were Beladi. All the plants of the "St. George" were covered with spots causing the plants to become stunted and the death of many leaves. Several of the "Laxton" plants growing within twelve feet of the "St. George" were badly attacked whilst the remainder of the plants in the rows were perfectly healthy. A few of the Beladi plants within about ten feet of the "St. George" variety were also attacked but to a lesser extent than the "Laxton." No cases of spotted leaves were found on any of the plants in the main crop. Several other crops were examined in the Gîza district but no disease was found.

It is possible, indeed probable, that in damp environment the Beladi variety might contract the disease more or less seriously but normally it causes little or no damage. Unless "St. George" proves to have special qualities its growth should not be encouraged.

Spraying with Bordeaux mixture is known to be effective againts the leaf spot disease when treatment is necessary. Another method of treatment is to cut off all leaves at the end of the season and when dry to burn them. This destroys all the spores on the leaves which infect the young leaves in the following year.

MISCELLANEOUS.

Castor Oil (*Ricinus communis* L.).

Rust (*Melampsorella ricini* (Biv. Bern. de Toni).

The castor oil plant is not considered of much importance in Egypt and is found growing mostly on the slopes of the canal banks. In the spring and early summer the under surfaces of the leaves are covered with rust pustules which cause them to lose their colour, shrivel, and dry up. The damp situations in which the plants grow, of course, favour the rust attack. As in all other countries where the disease is known, only the uredo stage of the fungus is known in Egypt.

Darnel Grass (*Lolium temulentum* L.).

Poisonous Fungus.

In 1920 several cases of poisoning occurred in villages in some localities, and samples of bread, flour, and wheat were received from the Public Health Department for investigation. The mixture of grain from which the bread had been made consisted mainly of wheat and seeds of darnel grass. Microscopic examination of the latter showed the presence of fungus hyphae in the tissues of the seed. The fungus is also known to occur in the seeds of *Lolium perenne* L. and *Lolium italicum*. The presence of the fungus does not injure the plant and experiments have shown that infected plants are much more vigorous than uninfected. Thus the relationship between the plant and the fungus is one of symbiosis. When the seed is sown the fungus mycelium grows inside the tissues of the growing stem and keeps pace with it and eventually enters the tissues of the seed. Here it remains in a quiescent condition until the seed is sown in the following year when it resumes its activity as before. So complete is the symbiotic relationship between the fungus and the plant that the former does not produce any spores.

It appears that the darnel grass is divided into two classes, *viz.*: those which are invaded by the fungus which perpetuates itself from generation to generation as explained above; and the others which are free from the fungus and which cannot become infected. The presence of the fungus in the seed renders it poisonous and as shown by the cases in Egypt its poisonous effect is not destroyed by heat in baking.

Imperata cylindrica L.

Smut (*Sphaceolotheca schweinfurthiana* Thuem Sacc.).

This grass grows as a weed on the canal banks and is very badly attacked by the smut disease. It is, however, of little or no importance economically.

Melilotus spp.

Downy Mildew (*Peronospora trifoliorum* De Bary).

Slight attacks of the downy mildew are found on the under surfaces of the leaves. It is not important.

Opium Poppy (*Papaver somniferum* L.).

Downy Mildew (*Peronospora arborescens* Berk. De Bary).

The opium poppy is mostly grown in Upper Egypt on small areas along the banks of the Nile. The mildew attacks the leaves of the plants when they are almost fully grown. The lower leaves suffer mostly and the mildew often causes these to wither and dry up. Only small areas of the upper leaves are affected. The fungus is visible with the naked eye on the lower surface of the leaves. The system in Egypt is to thin out the crop when young and this probably allows a free passage of air through the crop thus keeping down the disease. Spraying with Bordeaux mixture would probably check the disease but the cost of application is too great in proportion to the value of the crop.

Rose (*Rosa* spp.).

Mildew (*Sphærotheca pannosa* Wallr. Lev.).

The rose mildew occurs on the leaves, covering them with a whitish growth which consists of the conidiophores bearing conidia of the fungus. Like a good many other fungous diseases in Egypt the damage caused is generally slight except in the case of bushes grown in shaded and damp conditions. Dusting with sulphur or spraying the trees with an ammoniacal solution of copper carbonate are in general use as remedial measures against the disease.

Rust (*Phragmidium subcorticium* (Schrank) Wint.).

The remarks concerning damage caused by the mildew are also applicable to the rust. Remedial measures are not called for, and this is fortunate, since no direct method is at present known.

Leaf Blotch (*Actinonema Rosæ* (Lib.) Fr.).

This disease causes dark brown, almost black, patches on the upper surfaces of the leaves. It is of rare occurrence in Egypt and causes very little damage.

Sugar-cane (*Saccharum officinarum* L.).

Mosaic (*cause unknown*).

This disease is known to affect several different plants in various parts of the world. The natural result is that it has been described under several different names. In Germany it is generally known on tobacco as "Mosaikkrankheiten"; in France as "La Mosaïque" "Neille" and "Manche"; and in America as "Calico" or the "Frenching Disease." In other English-speaking countries it is generally known as the "Mosaic Disease." In Egypt it has been observed up to the present on sugar-cane, tobacco, and tomato. The little attention which has been given to this disease or diseases in this country has been confined to the sugar-cane. Its distribution is general and as has been done previously in other countries it has been demonstrated by experiment that cuttings from diseased plants produced diseased shoots regularly. It is not considered, however, to be of such importance in Egypt as in Trinidad (40). The disease is characterised by the appearance in the leaves of pale, yellowish green streaks. The streaking is much more apparent when the leaf is held up to the light, particularly in the case of the young leaves, where contrast in colour between diseased and healthy tissue is more marked. Williams (40) states that the disease can be controlled by destroying all diseased stools and by careful selection of cuttings from healthy plants. The same methods would undoubtedly eradicate the disease in Egypt but at present at any rate the damage caused is not sufficient to justify the Government spending the large sum which such treatment would cost.

Poplar (*Populus* spp.).

Bracket Fungus (*Polyporus hispidus* Fr.).

This fungus grows on the larger limbs and trunk of the poplar. It has only been observed in one locality in Egypt, *viz.* : the Zoological Gardens, Gîza. It is most destructive, since an attack low down on a big limb means the death of all wood above that point. Remedial treatment consists of (i) removing the fungus-fruiting body and burning it ; (ii) sawing off the parts affected about two feet below the point of attachment of the lowest fruit body and utilising as fuel ; (iii) tarring the cut ends of all branches with tar or creosote so as to prevent fresh infection.

Root-rot (*Armillaria mellea* Vahl.).

The popular name for this fungus is the "Honey Agaric." Like the bracket fungus it has only been found in Egypt attacking poplars in the Zoological Gardens, Gîza. It grows in clumps round the bases of the trees generally, but sometimes some distance from them. At first sight it would appear that the cluster of fruiting bodies grow saprophytically on the soil but on closer examination it will be found that they are attached to the roots of the tree. The fungus mycelium invades the bast tissues of the roots and sometimes the base of the trunk and obtains its nutriment from them. It gradually causes the death of the bast tissues of the roots and base of the trunk and the trees die in consequence. The fungus spreads from one tree to another by means of special organs, "Rhizomorphs," which grow in all directions in the soil. If treated at an early stage the disease can be checked by cutting out and burning all diseased parts. All cut ends should be coated with tar or creosote and a trench about a foot deep dug round the tree so as to isolate it from the others. The trench will prevent the rhizomorphs from spreading to the other trees. In the case of the poplars at the Zoological Gardens, however, it would be better to fell them and replace them by other kinds of trees. The two diseases above mentioned will kill them eventually whatever steps are taken to combat them. The healthy wood could be utilized, whereas if the diseases are allowed to progress, little use could be made of it.

SAPROPHYTIC FUNGI.

No special attention has been given to the study of saprophytic fungi in Egypt. Apart from various species of Cladosporium, Alternaria, Fusarium, and such like minute fungi, the most interesting which have been collected are the following :—

Agaricus campestris (Common mushroom).
Coprinus atromentarius.
Coprinus comatus (Parasol mushroom).
Concibulum vulgare.

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DESCRIPTION OF PLATES.

Corticium vagum B and C.

PLATE I.

Fig. 1.—Scar produced on hypocotyl of cotton seedling at commencement of attack. (Natural size.)
„ 2.—More advanced stage of diesase. (Natural size.)
„ 3.—Last stage of disease showing collapsed seedling with yellow cotyledons. (Natural size.)

PLATE II.

Fig. 1.—Hyphæ in cortical cells of hypocotyl of cotton seedling. (×300.)
„ 2.—Brown hyphæ from surface of diseased cotton seedling. (×300.)
„ 3.—Basidia and basidospores from earth nut. (×580.)

PLATE III.

Fig. 1.—Brown hyphæ from culture on prune agar. (×650.)
„ 2.—Brown hyphæ from earth nut in connection with collapsed hyaline hyphæ. (×300.)
„ 3.—Hyaline hyphæ from earth nut. (×300.)
„ 4.—Triangular and barrel-shaped cells from culture on potato wedge. (×650.)

PLATE IV.

Fig. 1.—Pure culture on potato wedge. Fourteen days old. Sclerotia formed. (Natural size.)
„ 2.—The same culture six weeks old. Largest sclerotium 15 millimetres in diameter. (Natural size.)
„ 3.—Pure culture on agar medium which had been allowed to dry slightly before fungus was placed in tubes. Culture four weeks old when drawn. Resting cells produced but no definite sclerotia. (Natural size.)
„ 4.—Pure culture on fresh agar medium. Culture four weeks old when drawn. Sclerotia formed. (Natural size.)

PLATE V.

Photomicrograph of sclerotium in section.

Rhizoctonia batiticola (Taub.) But.

PLATE VI.

Fig. 1.—Pure culture on potato wedge, one week old. (Natural size.)
„ 2.—Pure culture on prune agar. One week old. (Natural size.)

PLATE VII.

Fig. 1.—Portion of transverse section of root of loubia (*Vigna sinensis*) showing sclerotium in section in vessel. (×300.)

,, 2.—Portion of longitudinal section of root of loubia (*Vigna sinensis*) showing sclerotia in section. (×300.)

,, 3.—Hypha from culture 48 hours old on prune agar medium. (×500.)

,, 4.—Blackish hypha connecting sclerotia in an older culture on prune agar. (×500.)

PLATE VIII.

Fig. 1.—Hypha consisting of short barrel-shaped cells. This is a very early stage in the development of a sclerotium. (×650.)

,, 2.—Later stage in the development of sclerotium. (×650.)

,, 3.—Young sclerotium. The parent hypha and one of the side branches have now turned blackish. (×650.)

Fusarium vasinfectum.

PLATE IX.

Fig. 3.—Macroconidia of *Fusarium vasinfectum* Atk. (×400.)

,, 4.—Conidia of *Fusarium vasinfectum* Atk. intermediate in form between macro and micro-conidia. (×400.)

,, 5.—Micro-conidia of *Fusarium vasinfectum* Atk. (×400.)

Sclerotium Rolfsii (Sacc.)

Fig. 1.—Portion of mycelium showing clamp connections formed in culture. (×665.)

,, 2.—Portion of mycelium from artichoke root. (×665.)

PLATE X.

Portion of globe artichoke root with mycelium and sclerotia growing over the surface. (Natural size.)

Pseudomonas tritici (Hutchinson).

PLATE XI.

Two diseased ears of Indian wheat attacked by *Pseudomonas tritici* (Hutchinson). (Natural size.)

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PLATE I.

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PLATE II

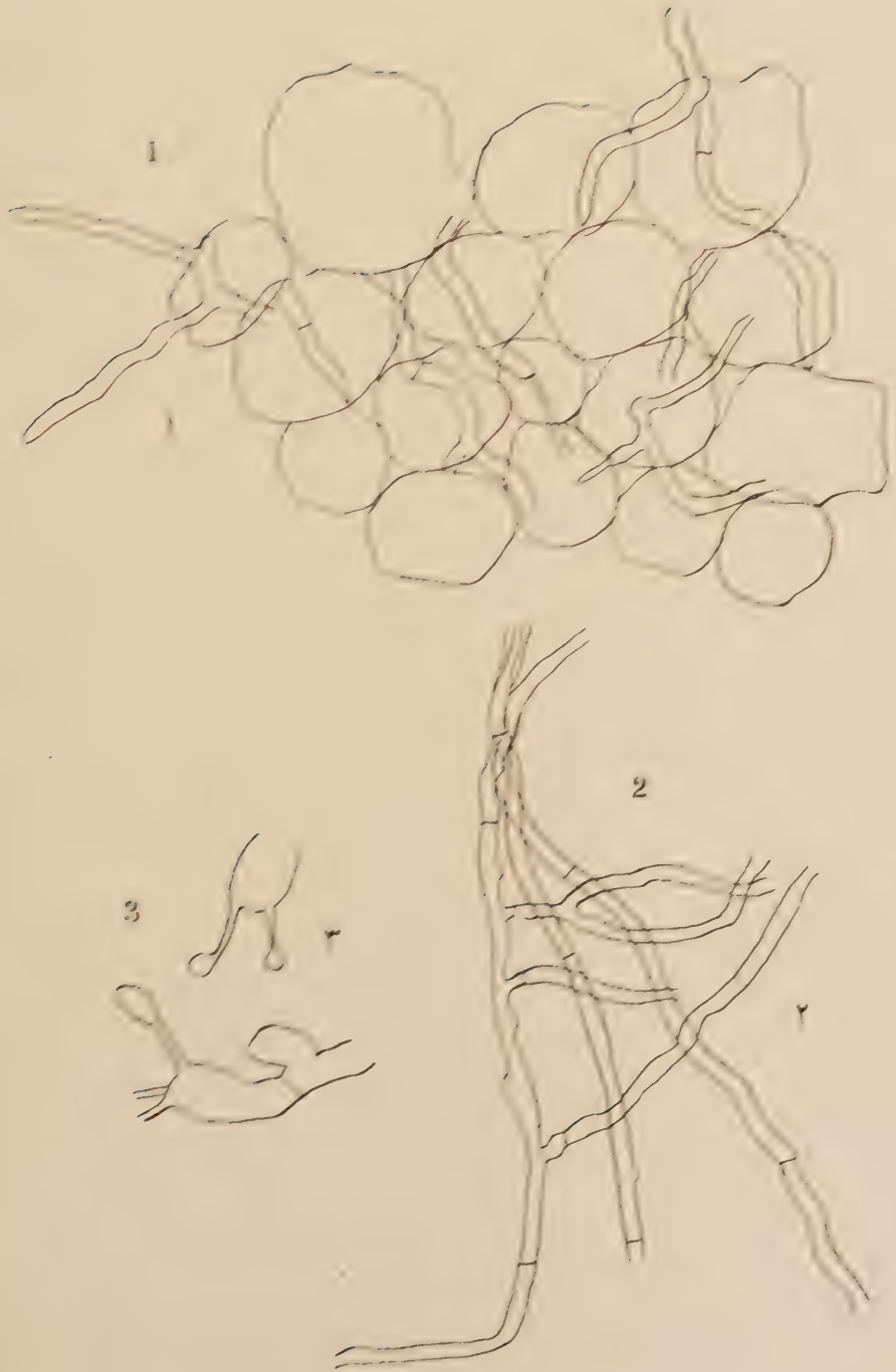

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PLATE III.

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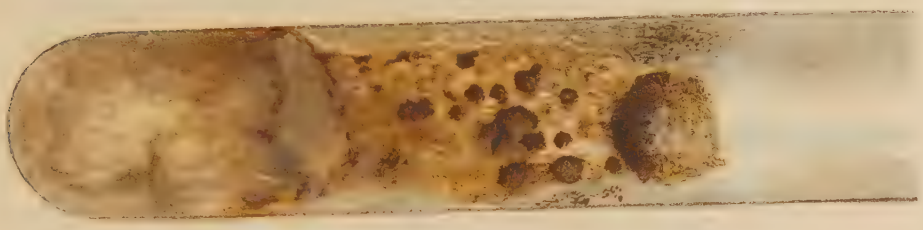

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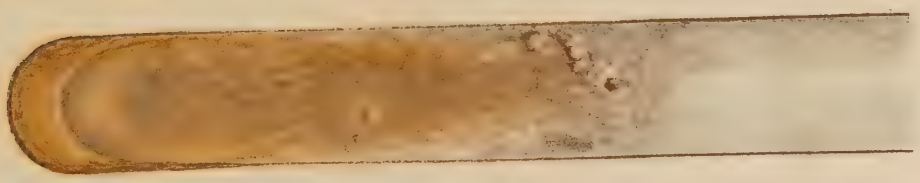

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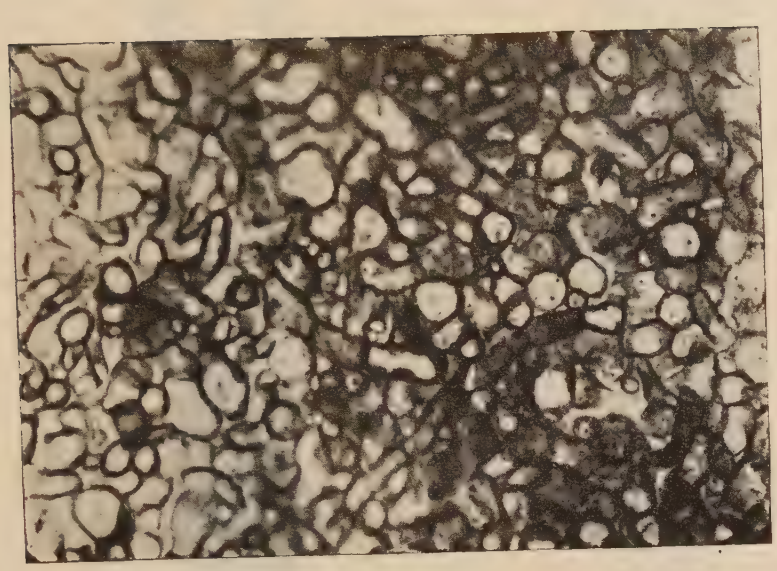
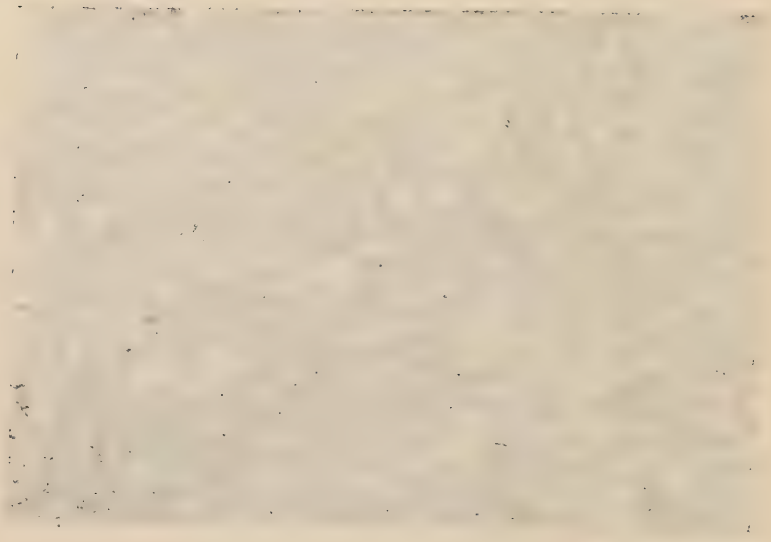
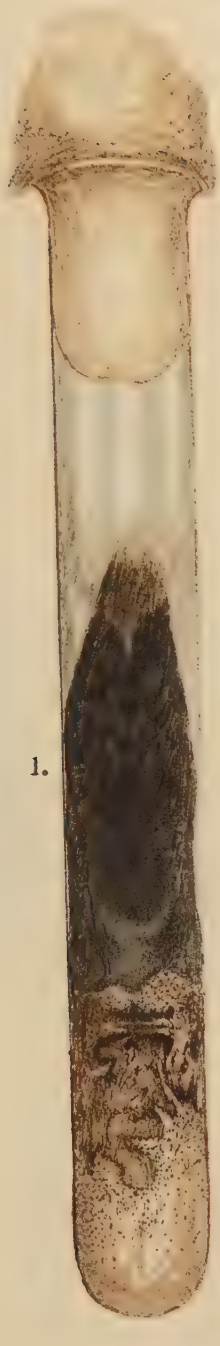
PLATE V.







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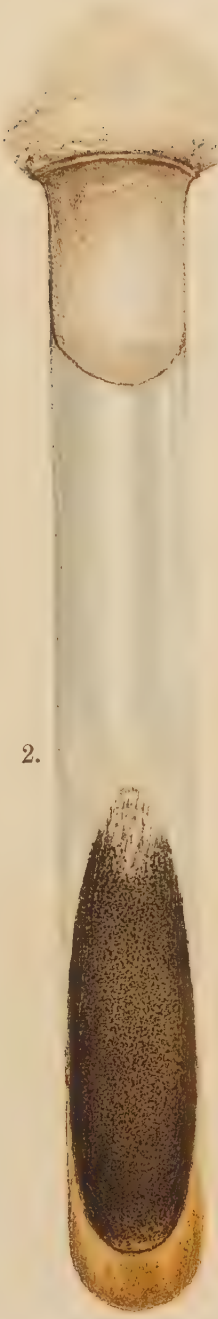

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PLATE VII.

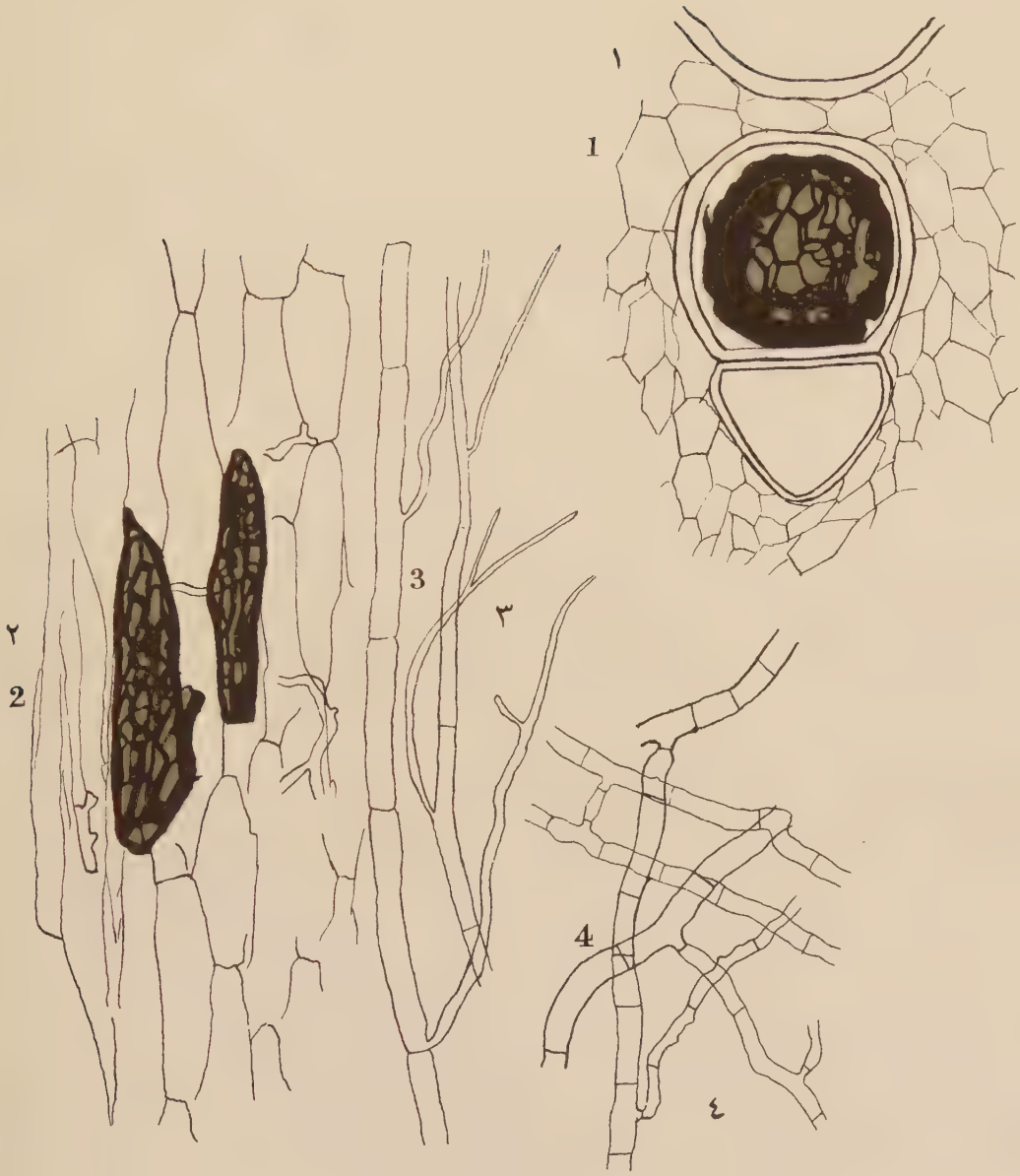

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PLATE VIII.

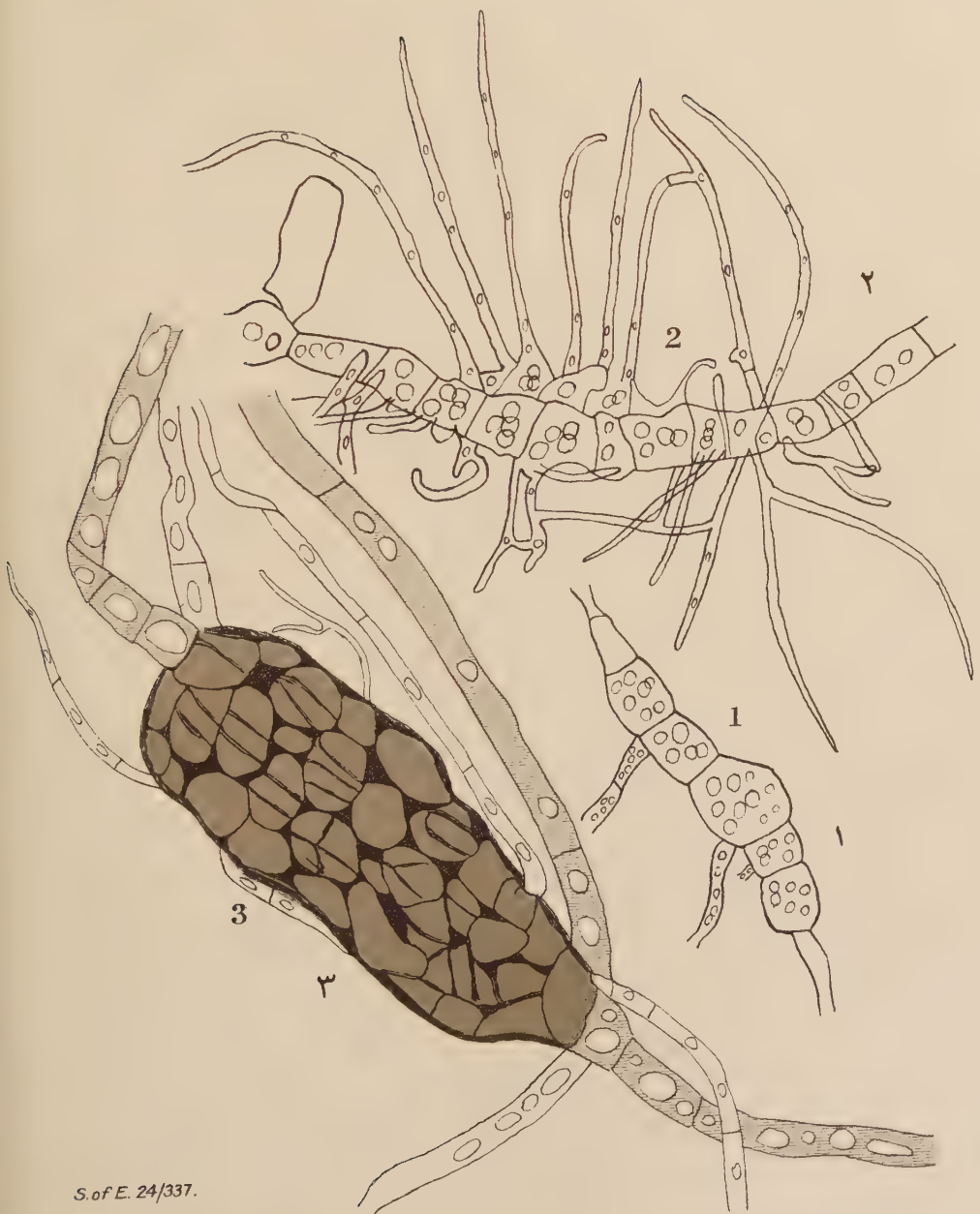

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PLATE IX.

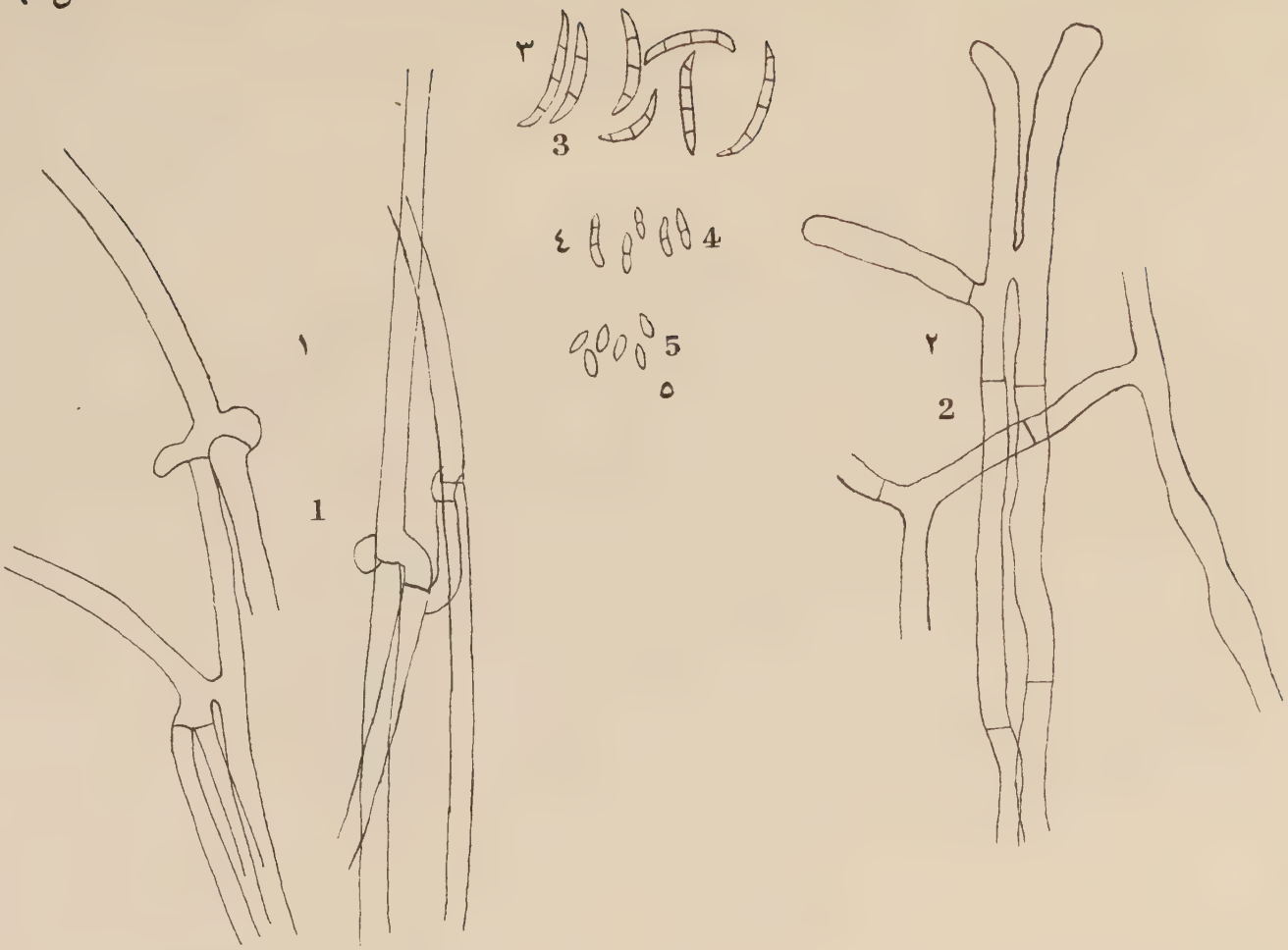

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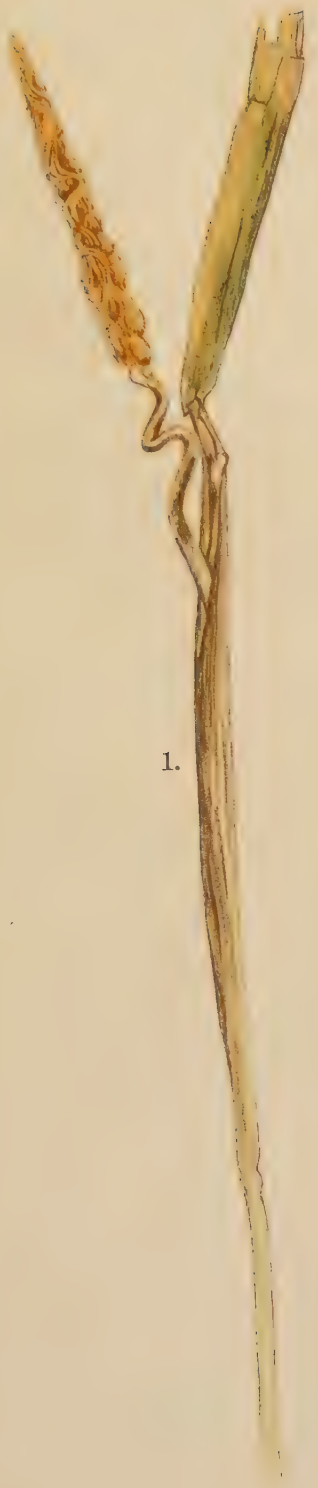
PLATE XI.



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MINISTRY OF AGRICULTURE, EGYPT.

List of Publications in English issued by the Ministry.*

The following publications may be obtained, either directly, or through any bookseller, from the Government Publications Office, Ministry of Finance (Dawawîn P.O.), Cairo.

Agricultural Journal of Egypt.

First Series.

Vol. I, 1911. Parts I and II, P.T. 2† each part.
„ II, 1912. Part I P.T. 2; Part II, P.T. 3.
„ III, 1913. Parts I and II, P.T. 3 each part.
„ IV, 1914. Parts I and II, P.T. 3 each part.
„ V, 1915. Parts I and II, P.T. 5 each part.

In 1923 a new series was started monthly in Arabic only. An English edition is published once a year containing articles selected from the year's Arabic issues.

New Annual Series.

Vol. I, 1923 (in the press).

Egyptian Agricultural Products (By Gerald C. Dudgeon).

No.
1 A. The Great Millet (*Durra Baladi* or *Durra Rafî'a*) in Egypt. P.T. 3.
2 A. The Ground Nut or Earth Pea (*Fûl Sudani*) in Egypt. P.T. 2.
3 A. Gossypium Spp., Cotton (*Qotn* in Egypt). History, Development, and Botanical Relationship of Egyptian Cottons, with tables showing Areas, Yields, Prices, and Distribution of the Varieties. P.T. 5.

Technical and Scientific Bulletins.

No.
1. Report on the First two Years' Working of the Plant Protection Law (Law No. 5 of 1913), by G. Storey. (English or French.) 1916. P.T. 2.
2. The Nature of the Damage done by the Pink Boll Worm (*Gelechia gossypiella* Saund.), by Lewis Gough. (English or French.) 1916. P.T. 1.
3. Note on the Alkaloids of some Egyptian Solanaceæ, by Frank Hughes. (English or French.) 1916. P.T. 1.

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* Revised to May 2, 1925.

† P.T. 1 = 5 cents = 2½*d.* approximately.

TECHNICAL AND SCIENTIFIC BULLETINS (*continued*).

No.

4. The Life History of *Gelechia gossypiella* from the Time of the Cotton Harvest to the Time of Cotton Sowing, by Lewis Gough. 1916. P.T. 1.
5. List of Egyptian Insects in the Collection of the Ministry of Agriculture by G. Storey. 1916. P.T. 10.
6. Note on a Machine to kill *Gelechia* Larveæ by Hot Air, and the Effects of Heat on *Gelechia* Larvæ and Cotton Seed, by Lewis Gough. 1916. P.T 2.
7. Work in Connection with Egyptian Wheat, by G. C. Dudgeon and B. G. C. Bolland. 1916. P.T. 1.
8. Work conducted at the Experimental Farm at Gîza in connection with Great Millet and *Bersîm*, by B. G. C. Bolland. 1916. P.T. 1.
9. Work in connection with Egyptian Maize, by G. C. Dudgeon and B. G. C. Bolland. 1916. P.T. 1.
10. Some Tests of Flour made from Egyptian Wheat, by Frank Hughes. 1916. P.T. 1.
11. Simon's Hot Air Machine for the Treatment of Cotton Seed against Pink Boll Worm, by G. Storey. 1921. P.T. 1.
12. Experiment with Flax growing at the Government Farm at Gemmeiza, by G. C. Dudgeon. 1917. P.T. 2.
13. The Rate of Increase of the Pink Boll Worm in 1916, by Lewis Gough. 1917. P.T. 2.
14. Machines for the Treatment of Cotton Seed against Pink Boll Worm (*Gelechia gossypiella* Saund.), by G. Storey. 1921. P.T. 2.
15. Rusts and Smuts of Wheat, Barley, and Oats, by H. R. Briton-Jones. 1920. P.T. 2.
16. The Present Situation with regard to the Control of the Pink Boll Worm in Egypt, by G. Storey. 1921. P.T. 2.
17. The Hibiscus Mealy Bug, by W. J. Hall. 1921. P.T. 3.
18. The Smuts of Millet, by H. R. Briton-Jones. 1922. P.T. 3.
19. A Wound Parasite of Cotton Bolls, by H. R. Briton-Jones. 1923. P.T. 3.
20. The Fixation of Atmospheric Nitrogen, by Frank Hughes. 1922. P.T. 3.
21. Report on a Soil Survey of Zone No. 1 (Gharbîya), 1921, by Frank Hughes. 1922. P.T. 5.
22. Observations on the Coccidæ of Egypt, by W. J. Hall. 1922. P.T. 5.
23. (*Stopped.*) Subsequently published by the Société Entomologique d'Egypte. 1922, under the title: A Monograph of the Egyptian Diptera (Part I, fam. Syrphidæ), by H. C. Efflatoun.
24. On the Dispersion of the Pink Boll Worm in Egypt, by Lewis Gough. 1922. P.T. 5.
25. The Basis of Egyptian Agriculture and its Relation to the Decline in the Average Yield per Feddân of Cotton, by E. McKenzie-Taylor and A. Chamley Burns. 1922. P.T. 5.
26. The Outbreak of Pseudococcus sacchari on the Sugar Cane of Egypt, by W. J. Hall. 1922. P.T. 3.
27. Statistics of Pink Boll Worm Occurrence from 1916–1921, by the Entomological Section. 1923.
28. A New Type of Light Trap for Insects, by C. B. Williams. 1923. P.T. 3.

Technical and Scientific Bulletins (*continued*).

No.

29. A Short Bio-Climatic Study in the Egyptian Desert, by C. B. Williams. 1923. P.T. 5.
30. On Banana Disease caused by a Species of "Heterodera," by Tewfik Eff. Fahmy. P.T. 5.
31. Soil Temperatures during the *Sharâqi* Period and their Agricultural Significance, by E. McKenzie-Tayolr and A. Chamley Burns. 1924. P.T. 5.
32. The Cotton Plant in Relation to Temperature and Rainfall, by C. B. Williams. 1923. P.T. 2.
33. Preliminary Notes on Two Minor Pests of the Egyptian Cotton Crop (*Creontiades pallidus*, Ramb., and *Nezara viridula*, L.), by T. W. Kirkpatrick. 1923. P.T. 3.
34. Preliminary Note on the Soil Temperature in *Sharâqi* Land, by E. Mckenzie-Taylor and A. Chamley Burns. 1924. P.T. 5.
35. The Egyptian Cotton Seed Bug (*Oxycarenus hyalinipennis*, Costa). Its Bionomics, Damage, and Suggestions for Remedial Measures, by T. W. Kirkpatrick. 1924. P.T. 10.
36. Further Observations on the Coccidæ of Egypt, by W. J. Hall. 1924. P.T. 5.
37. Bioclimatic Observations in the Egyptian Desert in March 1923, by C. B. Williams. 1924. P.T. 5.
38. A Multiple Temperature Incubator, by C. B. Williams and T. W. Kirkpatrick. 1924. P.T. 3.
39. A Preliminary Note on the Loss by Boll Worms, by Ibrahim Eff. Bishara. 1924. P.T. 5.
40. A Comparison of Sand and Soil Temperatures in Egypt, by E. McKenzie-Taylor and C. B. Williams. 1924. P.T. 5.
41. Some New and Interesting Orthoptera in the Collection of the Ministry of Agriculture, Cairo, by B. P. Uvarov. 1924. P.T. 5.
42. Experiments to determine the Susceptibility of Weaned Calves to Cattle Plague, the Calves being doubly inoculated while suckling with Virulent Cattle Plague Blood and Serum, by Mohamed Askar Bey. 1924. P.T. 3.
43. Date Palm in Egypt, by T. W. Brown. 1924. P.T. 5.
44. The Propagation and Cultivation of Citrus Trees in Egypt, by T. W. Brown. 1924. P.T. 5.
45. The Insect Pests of Citrus Trees in Egypt, by W. J. Hall. 1924. P.T.5.
46. Four New Species of Coccidea from Egypt, by W. J. Hall. 1924. P.T.5.
47. Cotton Growing in relation to Climate in Egypt and the Sudan, by C. B. Williams. P.T. 5.
48. The Effect of Heat Treatment of Cotton Seed on its Germination and the Subsequent Growth and Development of the Plants, by J. Templeton. P.T. 5.
49. Mycological Work in Egypt, by H. R. Briton-Jones. P.T. 5.
50. Third Bioclimatic Study in the Egyptian Desert, by C. B. Williams. P.T. 5.
51. Statistical Note on the Cotton Variety tests at Sakha, 1916–1920, by T. Trought. P.T. 5.
52. The Effect of the Summer fallow upon Soil Protozoa in Egypt, by E. McKenzie-Taylor and A. Chamley Burns. 1924. P.T. 5.
53. The Effect of Irrigation upon Soil Temperatures, by E. McKenzie-Taylor. P.T. 2.
54. Notes on the Fungus Rhizopus Nigricans, Ehr., in Relation to Insect Pests of the Cotton Plant in Egypt, by T. W. Kirkpatrick. P.T. 5.
55. Ratoon Cotton in Egypt. A Preliminary note, by J. Templeton. P.T. 5.

Technical and Scientific Bulletins (*continued*).

No.

56. The Buff-Backed Egret (*Ardea Ibis*, L. Arabic *Abu Qerdan*) as a Factor in Egyptian Agriculture, by T. W. Kirkpatrick. P.T. 5.
57. The Effect of the Sharâqi Period upon the Yield of Cotton in Egypt, by E. McKenzie-Taylor. (In the Press).
58. The Survival of Pink Boll Worm Larvæ in Buried Seed during the Winter in Egypt, by C. B. Williams. (In the Press.)
59. Hypertrophied Lenticels on the Roots of Cotton Plants, by J. Templeton. (In the Press).
60. The Development of the Egyptian Cotton Plant, by M. A. Bailey. (In the Press.)
61. A note on the Abnormal Behaviour of Cotton Plants when subjected to Handling, by M. A. Bailey. (In the Press).
62. Report on a Mission to California (U.S.A.) to study New Methods of Fumigation of Citrus Trees, by Neguib Eff. Iscander. (In the Press).
63. An Account of Experiments carried out to Determine the Experimental Error of Field Trials with Cotton in Egypt, by M. A. Bailey. (In the Press).
64. Notes on Egyptian Coccidae with Descriptions of New Species, by W. J. Hall. (In the Press).

— Special Bulletin, Egyptian Commercial Cotton, by G. C. Dudgeon. (English and French.)

Entomological Pamphlets.

No.

1. Egyptian Insect Pests. "Termites." P.T. 2.
2. Egyptian Insect Pests. "The Australian Fluted Scale." P.T. 2.
3. The Black Scale. P.T. 1.
4. The Red Scale (*Aspidiotus aurantii*, Mask). P.T. 1.
5. The Orange Mussel Scale (*Mytilaspis beckii*, Newm.=*citricola*, Pack.) P.T. 1.

Leaflets of the Mycological Division.
Botanical Section.

No.

1. The Downy Mildew of Vine.
2. How to control Plant Diseases by Spraying and Dusting.
3. Machines for Spraying and Dusting Diseased Crops.
4. The Eel Worm Disease of Wheat.
5. The Smuts of Wheat.
6. The Smuts of Millet.
7. The Smuts of Barley. (Under preparation.)
8. Mildews which attacks Plants of the Gourd Family. (Under preparation.)
9. Seed Steeping and Seed Sprinkling. (Under preparation.)

Obtainable free of charge from the Mycological division, Botanical Section, Gîza.

Leaflets of the Horticultural Section. By T. W. Brown, Director, Horticultural Section. P.T. 1, unless stated otherwise.

(*No number.*) Citrus Trees.

No.

1. French Beans (*Fasoolia*).
2. Asparagus (*Kishk Almaz*).
3. Preservation of Dates.
4. Egyptian Arum (*Qolqas*).
5. Cultivation of Potatoes.
6. Preservation of Apricots.
7. Custard Apple.
8. List of Trees, Shrubs, and other Perennial Plants cultivated in the Ministry's Garden at Gîza.
9. Globe Artichoke (*Kharshûf*).
10. Strawberries (*Shouleik* or *Frawla*).

No.

11. Tree Planting on Agricultural Estates and Roads. P.T. 5.
12. Simple Instructions for preserving Tomatoes.
13. Quince.
14. Egg-plant.
15. Manuring of Vegetables.
16. Chillies and Peppers.
17. The Insect-powder Plant (*Chrysanthemum pyrethrum cinerariæfolium.*) P.T. 2.

Plant Introduction. (By Horticultural Section.)
No. 1, July 1919; No. 2, July 1920; No. 3, July 1921. P.T. 2 each.

Laws and Regulations.
Price P.T. 2 each, unless stated otherwise.

Regulations of the Boll Worm and Seed Worm Campaign, 1915, 1916, 1917.
Regulations of the Cotton Worm Campaign, 1915, 1916.
Regulations of the Boll Worm Campaign, 1917.
Législation Agricole et Vétérinaire. (French.) 1923. P.T. 10.

Administrative and Technical Reports.

Annual Report of the Veterinary Service, 1913. P.T. 2.
The same, 1914, 1915, 1916, 1917, 1918–1919, 1919–1920, 1920–1921. P.T. 5 each.
Report on the Great Invasion of Locusts in Egypt in 1915. P.T. 5.
Rapport sur les Travaux de la Commission du Commerce Agricole, 1916–1917. (French.)
Report on the Maintenance and Improvement of the Quality of Egyptian Cotton and the Increase of its Yield, by A. Martin Leake. 1912. P.T. 5.
The Pink Boll Worm in Egypt in 1916–1917, by H. A. Ballou, 1920. P.T. 10.
Report on the Motor Tractor Trials organized by the Ministry of Agriculture. P.T. 15.

Cotton Research Board.

Preliminary Report on the Cotton Research Board. P.T. 3.
First Annual Report of the Cotton Research Board, 1920. P.T. 10.
Second Annual Report of the Cotton Research Board, 1921. P.T. 10.
Third Annual Report of the Cotton Research Board, 1922. P.T. 15.

Egyptian Agricultural and Veterinary Notes.

Wheat Rust. P.T. 1.
Wheat Smut. P.T. 1.
Notes on Samples of Fertilizers and Substitutes examined at the Laboratories on the Chemical Section during 1918. P.T. 2.

Egyptian Agricultural and Veterinary Notes (*continued*).

Analytical Key to the Flora of Egypt, by M. Tewfik Hafnawi. P.T. 5.
The Method employed by the State Domains for producing and maintaining their High Standard of Sakel Cotton. P.T. 2.
Nitrate of Lime. P.T. 2.
Ageing Egyptian Cattle, by Mohammed Askar Bey. P.T. 2.
The principal Species of Birds Protected by Law in Egypt. Giving their English, French, Arabic, and Scientific Names, their local status, their approximate size, and concise notes on their Coloration, for purposes of identification by S. S. Flower, and H. J. Nicoll. P.T. 5.

Agricultural Circulars.

The following circulars have been issued gratis in English :—

No.
3. *Assîli* Cotton.
5 Cultivation of Castor-oil Plants (*Ricinus communis*).
8. Manner of Distinguishing between the Useful Ladybird and the Injurious Melon Beetle.
17. The Cotton Worm, its Destruction and Best Method of obtaining a Good Yield.
19. Cotton Cultivation in Upper Egypt.
20. Protection of the Buff-backed Egret. (English and French.)
21. Hints on Cotton-growing in Egypt.
22. On using Nitrate of Soda in Maize Cultivation in Gîza Province.
26. Steps to combat the Cotton Boll Worm in May, June, and July.
27. Paraffin Emulsion. (English and French.)
29. Sowing Vegetable Seeds in Winter.
30. The Danger of Overwatering Cotton Fields.
35. Distribution of Cotton Seed.
37. Fumigation of Citrus Trees.
38. Pomegranate Worm.
39. The Smut Diseases.
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